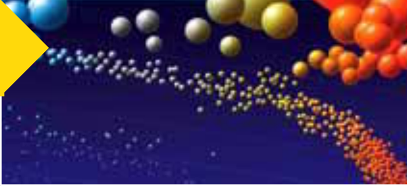
BONUS FOLDOUT POSTER: everything on stars!



April 2006

Astronomy®

Observing, telescopes, origin and fate of the cosmos

SPECIAL ISSUE

All about stars

- Extreme stars — biggest, brightest, and strangest
- Live fast, die young — lives of massive stars
- Meet the 59 nearest stars
- How the North Star is changing before our eyes

Explore the Virgo cluster of galaxies p. 68

OBSERVING TREATS

High Moon: great views ahead

PLUS:

Southern-sky wonders photo gallery

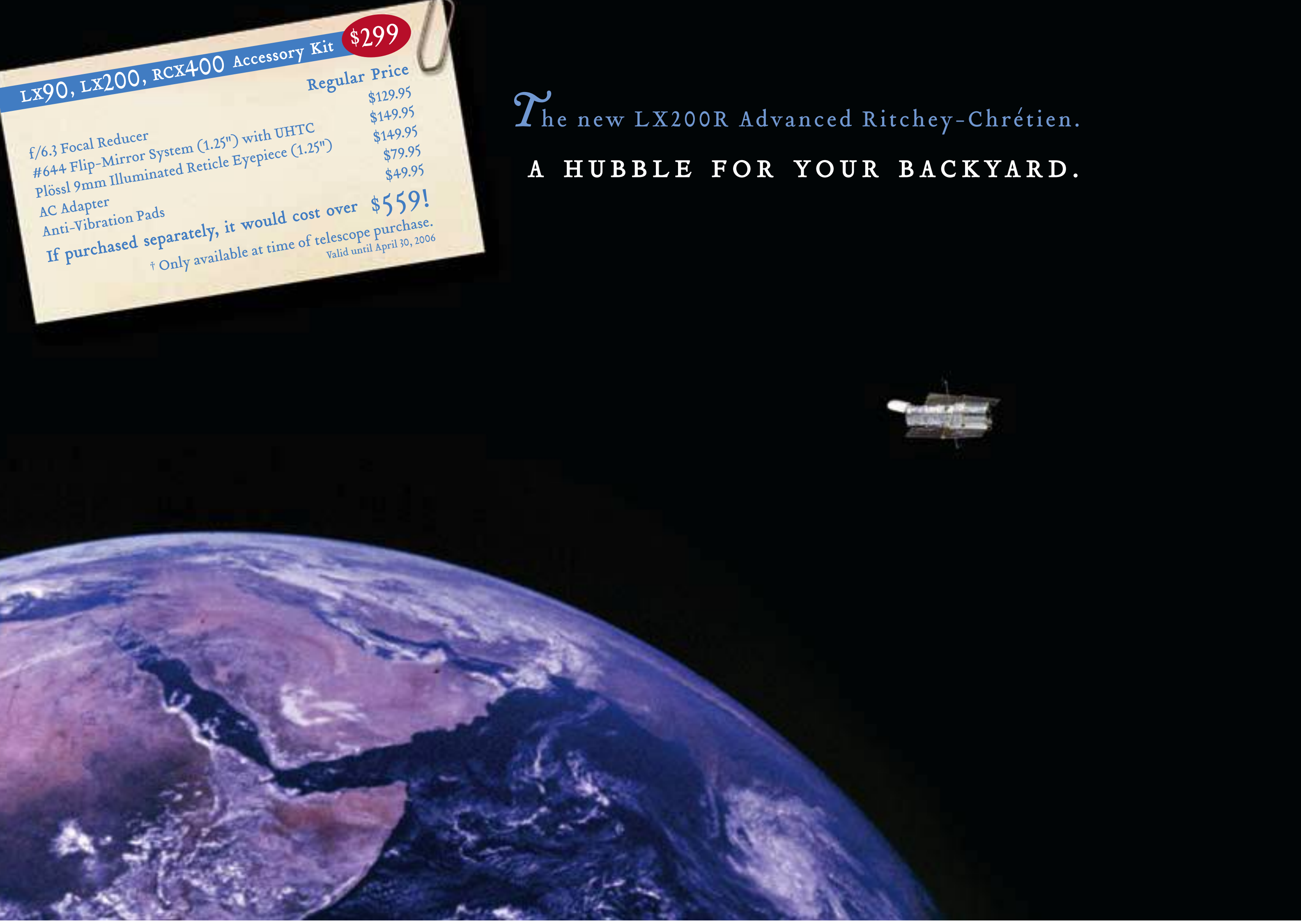
Testing a new go-anywhere scope

Young stars emerge from pillars of cool gas and dust in the W5 region of Cassiopeia.

Astronomy.com

$6.95 U.S. • $7.95 CANADA

Vol. 34 • Issue 4



LX90, LX200, RCX400 Accessory Kit $299

	Regular Price
f/6.3 Focal Reducer	$129.95
#644 Flip-Mirror System (1.25") with UHTC	$149.95
Plössl 9mm Illuminated Reticle Eyepiece (1.25")	$149.95
AC Adapter	$79.95
Anti-Vibration Pads	$49.95

If purchased separately, it would cost over $559!

† Only available at time of telescope purchase. Valid until April 30, 2006

The new LX200R Advanced Ritchey-Chrétien.

A HUBBLE FOR YOUR BACKYARD.

ALL-NEW OPTICAL SYSTEM

LX200R™ The most widely used research telescope on earth now comes with the most advanced optical system in space. Meade's all new LX200R brings Advanced Ritchey-Chrétien optics within reach of aspiring astronomers everywhere. Nearly every observatory reflector in the world is a Ritchey-Chrétien, including NASA's Hubble Space Telescope. Now you can own what the professionals own. The LX200R includes all the field-proven features of the LX200 including GPS, Primary Mirror Lock, Zero Image-Shift Microfocuser, Oversized Primary Mirror, SmartDrive™, Smart Mount™, AutoStar® II and more. Plus, the LX200R comes with observatory-class optics crafted in Irvine, California, and a Series 5000 26mm 5-Element Plössl eyepiece. The new LX200R. It's the biggest news in astronomy since, well, the LX200.

	8"	10"	12"	14"	16"
» Focal Ratio	F/10	F/10	F/10	F/10	F/10
» Price	$2,499	$3,399	$4,399	$5,999	$11,999
» UHTC™	$175	$235	$295	$350	$495
» OTA w/UHTC	$1,249	$1,799	$2,649	$3,699	$7,499

MEADE®

PRICES INCLUDE SHIPPING AND HANDLING

MEADE.COM | 800.919.4053

TELESCOPES.COM (800.958.6040) • ASTRONOMICS (800.356.6603) • OPTICS PLANET (888.263.0356) • OPT CORP. (800.338.9638)
SCOPE CITY (800.235.3344) • ADORAMA (800.223.2500) • B&H PHOTO (800.329.0315) • CANADA – EFSTON SCIENCE (888.396.3233)

30-06005.

WE BELIEVE SOME EXTRA HOURS OF OPTICAL ENGINEERING ARE JUSTIFIED IN A PRODUCT DESIGNED TO COST YOU THOUSANDS OF HOURS OF SLEEP.

MADE IN U.S.A.

Model	Price
ETX-90PE: *UHTC: $50*	$699*
ETX-105PE: *UHTC: $75*	$899*
ETX-125PE: *UHTC: $95*	$1099*

** ALL PRICES INCLUDE SHIPPING AND HANDLING.*

Astronomers spend a lot of prime sleeping hours exploring the heavens. It's our job to provide crystal clear views that make those hours of lost sleep worthwhile. In a world where quality optics are routinely sacrificed on the altar of offshore production and increased profit, we stubbornly continue to hand craft the optics of every ETX Maksutov-Cassegrain telescope right here in Irvine, California. Obsessive little things like oversized primary mirrors, premium-grade optical glass, ridiculously small engineering tolerances and high-transmission optical coatings add up to make a real difference in clarity, contrast and resolution. One we hope you'll enjoy night after sleepless night.

ETX® PREMIER EDITION

TRUE PLUG-AND-PLAY IS HERE.

MEADE
COMPUTER CONTROL

MEADE OPTICS HAVE NO EQUAL

Beware of cheap knock-offs from Asia with chromatic aberration, astigmatism, and other optical problems. Meade's U.S.–made Maksutov-Cassegrain optics are leading the industry. You get what you pay for.

MEADE.COM

800-919-4053

Telescopes.com
800-958-6040

Scope City
800-235-3344

Astronomics
800-356-6603

Adorama
800-223-2500

Optics Planet
888-263-0356

B&H Photo
800-329-0315

OPT Corp.
800-338-9638

CANADA
Efston Science
888-396-3233

MEADE®

Patents: 6,304,376; 6,392,799; 6,563,636; D422,610; and other patents pending. 30-06003.

BONUS FOLDOUT POSTER: everything on stars!
Astronomy
SPECIAL ISSUE
All about stars
Explore the Virgo cluster of galaxies
High Moon: great views ahead
PLUS:

NASA/JPL-CALTECH/L. ALLEN (HARVARD-SMITHSONIAN CfA)

ON THE COVER

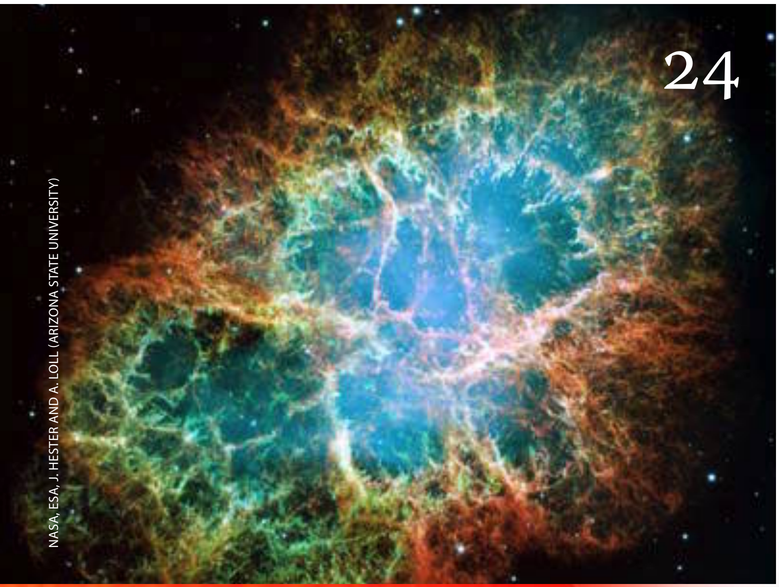
A massive cloud of gas and dust is collapsing 7,000 light-years away, giving birth to a new generation of stars. This infrared view, taken with the Spitzer Space Telescope, penetrates much of the dust and reveals many newly formed stars. This special issue covers everything you've ever wanted to know about stars.

VOL. 34, NO. 4

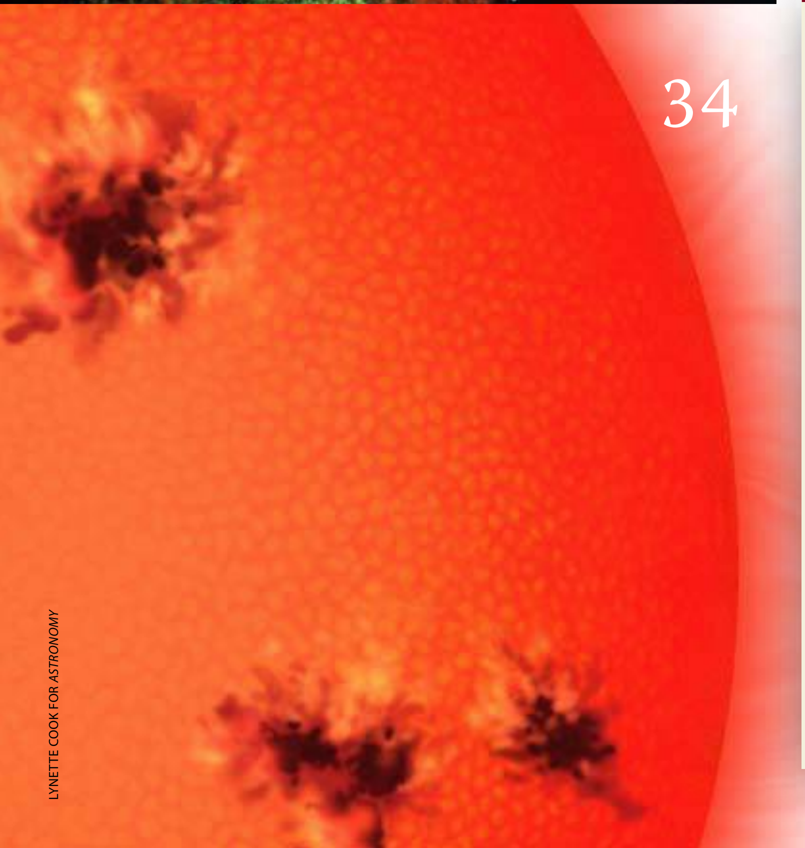
Astronomy®

Observing, telescopes, origin and fate of the cosmos

april 2006



NASA, ESA, J. HESTER AND A. LOLL (ARIZONA STATE UNIVERSITY)



LYNETTE COOK FOR ASTRONOMY

06 **This month in *Astronomy***
The stars special issue

10 **Beautiful universe**

14 **Letters**

16 **Bob Berman's strange universe**

18 **Glenn Chaple's observing basics**

20 **Phil Harrington's binocular universe**
ONLINE EXTRA: Find more binocular targets inside the Crab.

24 **Astro news**
Best-ever view of the Crab Nebula, and more

/// SPECIAL STARS ISSUE

34 **X-treme stars of the cosmos**
Get to know the galaxy's biggest, hottest, and most distant stars. **C. RENÉE JAMES AND HOWIE MARION**
ONLINE EXTRA: Observe extreme stars tonight.

40 **Live fast, die young**
Astronomers don't understand massive stars — rare beasts with short lives but lasting impact. These 10 questions rank among the most baffling. **YAËL NAZÉ**
ONLINE EXTRA: Learn how these massive stars perplex astronomers.

46 **Meet the neighbors**
The nearest stars hide secrets that could help astronomers learn more about our Sun's place in the galaxy.
JAMES B. KALER

62 **All about the North Star**
Polaris, navigators' guiding light, is evolving right before astronomers' eyes. **KEN CROSWELL**
ONLINE EXTRA: Earth has had more than one North Star.

/// *ASTRONOMY* EXCLUSIVE:

"Making sense of stars" foldout poster

Get more from Astronomy.com

Astronomy magazine readers have access to premium online content at Astronomy.com.
You must have an Astronomy.com account to view this content.

To create an account, go to www.astronomy.com/register.

Subscribers: Click "Create Magazine Subscriber Account" and enter the customer number on your subscription label. You'll enjoy unlimited access to the web site for the life of your subscription.

Newsstand buyers: Click "Create Newsstand Buyer Account" and enter the access code **UR6V4A**. If you've previously registered as a newsstand buyer, log in, click "My Account," and enter the code above. You'll enjoy unlimited web-site access through the last day of the month listed on the cover.

ADDITIONAL ONLINE CONTENT Get involved! Search **Astronomy groups** for clubs, planetaria, nature centers, and science museums near you. And check out **Community events** for upcoming star parties.

HOW TO REACH US: *Astronomy* magazine,
Kalmbach Publishing Co., 21027 Crossroads Circle,
P. O. Box 1612, Waukesha, WI 53187
t} 262.796.8776 f} 262.798.6468
e} letters@astronomy.com

HAVE YOU MOVED? Send change-of-address notices to the above mailing address or to customerservice@kalmbach.com.

FOR ADVERTISING INFORMATION, contact Howard Hoerl, Advertising Sales Manager, 888.558.1544, x571.

HAVE AN ASTRONOMY QUESTION?
Send it to askastro@astronomy.com

52 The sky this month

The Moon caresses the Pleiades

MARTIN RATCLIFFE AND ALISTER LING

68 Explore the Virgo cluster

Challenge yourself and your equipment by targeting some faint but fascinating galaxies. **STEVE COE**

76 Ask Astro

Lunar shadows, globulars or galaxies, hidden in HUDF

78 High Moon

This month, the Moon climbs farther north than at any time since 1987 and offers observers great views.

MARTIN RATCLIFFE

ONLINE EXTRA: Learn the importance of sketching your observations.

82 Eye on the southern sky

From film to digital imaging, this Chilean amateur astronomer does it all. **DANIEL VERSCHATSE**

90 Two scopes in one

Starmaster's new go-anywhere scope is a quick-change artist with two mounting options. **VIC WINTER**

94 New products

- Mars Globe 20x
- SkyScout
- Binocular viewer for telescopes
- TV-60 Imaging System
- LightBridge Truss Tube Dobsonian
- Tracker Imaging Platform

96 Coming events

97 Advertiser index

101 Reader gallery

Great celestial images from our readers

MORRIS WADE/ADAM BLOCK/NOAO/AURA/NSF

DANIEL VERSCHATSE

PAOLO CANDY

BY DAVID J. EICHER

The stars special issue

We owe our existence on Earth to many things, not the least of which is the Sun, our local star. As the source of almost all the energy the solar system receives, it transforms our little blue planet into a habitable world that sustains and nurtures life. It warms us, lights our skies, and gives us power. Yet, the Sun is just one of hundreds of billions of stars in the Milky Way Galaxy.

In this special *Astronomy* issue, we pay homage to stars in the cosmos. You will notice, if you haven't thus far, the spectacular eight-page poster bound into the center of this issue. Unique to astronomy publications, "Making sense of stars" presents a stunning illustration by Lynette Cook, who has rendered a Hertzsprung-Russell diagram that shows the colors, magnitudes, and life-tracks of dozens of important and notable stars.

The special package of science stories on hot stellar topics is a treat: "X-treme stars of the cosmos" by astronomers C. Renée James and Howie Marion (page 34) reveals the record-holding stars in our galaxy in terms of mass, distance, chemistry, and temperature. "Live fast, die young" (page 40) by Yaël Nazé of the University of Liège, Belgium, describes the intense, short lives of massive stars.

Ever wonder about the local region of space that surrounds the Sun? University of Illinois astronomer James B. Kaler's "Meet the neighbors" (page 46) describes the 59 stars closest to our solar system and how their secrets could reveal much about the Sun itself. Included in this story is a new and unique 3-D illustration showing the arrangement of the nearest stars, executed by *Astronomy*'s talented illustrator, Roen Kelly.

Finally, this big package presents "All about the North Star" by astronomer and popular author Ken Croswell (page 62). Croswell describes how Polaris, the guiding light of many a past navigator, is evolving and perhaps brightening, giving astronomers a fabulous mystery to solve.

ASSOCIATE EDITOR
Laura Layton joins *Astronomy*.
ASTRONOMY: WILLIAM ZUBACK

In this special month of stars, please help me welcome our newest associate editor, Laura Layton. A native of the Chicago area, Laura earned a bachelor's degree in English and a master's in physics from Northern Illinois University. She taught astronomy at NIU and at San Diego State University. Laura also managed NIU's observatory. Most recently, she lived in San Diego, where she was a developmental editor for The Brain Store, commissioning and editing scientific books. She also worked as a science writer for a web site and a copy editor for a newspaper.

Laura's wide range of astronomical interests includes observational astronomy, astroimaging, planetary science, and large-scale structure. She also enjoys music, reading, and spending time with her family. Laura is a welcome addition to the staff of *Astronomy* — you will see her name and read her stories many times in the coming months and years.

Yours truly,

David J. Eicher
Editor

Astronomy
Volume 34, Number 4

Editor David J. Eicher
Art Director LuAnn Williams Belter

EDITORIAL STAFF
Managing Editor Dick McNally
Senior Editor Richard Talcott
Associate Editors Michael E. Bakich, Laura Layton, Francis Reddy
Copy Editor Laura Baird
Assistant Editors Liz Kruesi, Jeremy McGovern, Matt Quandt
Editorial Assistant Valerie Penton

ART STAFF
Assistant Art Director Tonya J. Limberg
Illustrators Theo Cobb, Terri Field, Kellie Jaeger, Roen Kelly
Production Coordinator Joni Hauser

CONTRIBUTING EDITORS
Bob Berman, Glenn F. Chaple, Jr., Stephen J. Edberg, Phil Harrington, David Healy, Ray Jayawardhana, Alister Ling, Steve Nadis, Tom Polakis, Martin Ratcliffe, William Schomaker, John Shibley

EDITORIAL ADVISORY BOARD
Buzz Aldrin, Marcia Bartusiak, Timothy Ferris, Alex Filippenko, Adam Frank, John S. Gallagher III, William K. Hartmann, Paul Hodge, Anne L. Kinney, Edward Kolb, Stephen P. Maran, S. Alan Stern, James Trefil

[Kalmbach Publishing Co.]
President Gerald B. Boettcher
Vice President, Editorial, Publisher Kevin Keefe
Vice President, Marketing Michael R. Stephens
Vice President, Advertising Scott Stollberg
Corporate Art Director Maureen M. Schimmel
Managing Art Director Michael Soliday
Production Manager Annette Wall
Corporate Circulation Director Michael Barbee
Group Circulation Manager Michelle Spehr
Circulation Coordinators Erin Gallaher, Jaclyn Witthuhn
Single Copy Sales Director Jerry Burstein

ADVERTISING DEPARTMENT
(888) 558-1544
Advertising Sales Manager Howard Hoerl
hhoerl@astronomy.com
Advertising Sales Representative Ken Kozerski
kkozerski@astronomy.com
Ad Services Representative Leah Hamann
lhamann@kalmbach.com

RETAIL TRADE ORDERS AND INQUIRIES
(800) 558-1544, ext. 818; outside the U.S. and Canada: (262) 796-8776, ext. 818

SPECIAL E-MAIL ADDRESSES
Ad Sales adsales@astronomy.com
Ask Astro askastro@astronomy.com
Books books@astronomy.com
Customer Service customerservice@kalmbach.com
Letters letters@astronomy.com
Products products@astronomy.com
Reader gallery readergallery@astronomy.com

The Audit Bureau

Editorial phone: (262) 796-8776; advertising: (888) 558-1544; customer service & sales: 800-533-6644; outside the U.S. and Canada: 262-796-8776, ext. 421, Monday through Friday, 8:30 A.M. to 5 P.M. CT, Fax: (262) 796-1615; E-mail: customerservice@kalmbach.com. Please include your name, mailing address, and telephone number with any correspondence. Copyright © 2006 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription rate: single copy: $5.95; 1 year $42.95, 2 years (24 issues) $79.95, 3 years (36 issues) $114.95; Canadian & foreign: 1 year $58, 2 years $110, 3 years $160. Payable in U.S. funds drawn on U.S. Banks. (Canadian price includes GST.) Expedited Delivery Service Surcharges: Domestic 1st Class $30 per year, Canadian air $30 per year, Foreign air, $60 per year. BN 12271 3209 RT. Not responsible for unsolicited materials.

ONLINE EXTRA
For more information, visit www.astronomy.com/toc.

LX90, LX200, RCX400 Accessory Kit $299

	Regular Price
f/6.3 Focal Reducer	$129.95
#644 Flip-Mirror System (1.25") with UHTC	$149.95
Plössl 9mm Illuminated Reticle Eyepiece (1.25")	$149.95
AC Adapter	$79.95
Anti-Vibration Pads	$49.95

If purchased separately, it would cost over $559!

† Only available at time of telescope purchase.

Valid until April 30, 2006

24 ORBITING REASONS

the new LX90GPS can locate over 30,000 objects including itself.

The NEW LX90GPS™ can do more than track satellites. It can communicate with them as well. Turn it on and the built-in Sony® GPS sensor immediately determines your precise date, time and location. Meade's patented Auto-Align™ then uses this info to align your scope for a tour of the most spectacular sights in the universe. With all the features of the legendary LX90 Schmidt-Cassegrain plus the ability to communicate with satellites, the new LX90GPS now has it all. When it comes to industry-leading American-made optics, depth of features, and value for your dollar, the LX90GPS is the best Schmidt-Cassegrain telescope you can find that can find itself.

MEADE®

MEADE.COM | 800.919.4053

	8"	10"	12"
FOCAL RATIO	F/10	F/10	F/10
PRICE	$1899	$2499	$2999
UHTC™	$175	$235	$295

SHIPPING AND HANDLING INCLUDED

- Schmidt-Cassegrain optical design
- Diffraction-limited optics
- AutoAlign™
- AutoStar® telescope controller
- Sony® GPS sensor
- Oversized primary mirror
- SmartDrive™ (Periodic Error Correction)
- 7°/sec Slew/GoTo speed
- Rigid double-tine fork mount
- LX200-series sturdy field tripod
- Red-dot finder & 8x50 optical finder
- AutoStar Suite™ AE

TELESCOPES.COM (800.958.6040) . ASTRONOMICS (800.356.6603) . OPTICS PLANET (888.263.0356) . OPT CORP. (800.338.9638)
SCOPE CITY (800.235.3344) . ADORAMA (800.223.2500) . B&H PHOTO (800.329.0315) . CANADA - EFSTON SCIENCE (888.396.3233)

30-06004

MEADE®

PREMIUM ACCESSORIES

www.meade.com/accessories or call 800-919-4053

Ultra Wide Angle Series 5000™

82°
AFOV

Focal Length	Barrel Size	AFOV	Price
4.7	1.25"	82°	$199
6.7	1.25"	82°	$199
8.8	1.25"	82°	$199
14	1.25"	82°	$199
18	1.25"	82°	$279
24	2.00"	82°	$399
30	2.00"	82°	$449

Ultra Wide Angle Set **$749**
Includes: 6.7, 18, 30mm and alumium case

Super Wide Angle Series 5000™

68°
AFOV

Focal Length	Barrel Size	AFOV	Price
16	1.25"	68°	$179
20	1.25"	68°	$199
24	1.25"	68°	$249
28	2.00"	68°	$279
34	2.00"	68°	$299
40	2.00"	68°	$399

Super Wide Angle Set **$599**
Includes: 16, 24, 34mm and alumium case

5 Element Plössl Series 5000™

60°
AFOV

Focal Length	Barrel Size	AFOV	Price
5.5	1.25"	60°	$89
9	1.25"	60°	$89
14	1.25"	60°	$89
20	1.25"	60°	$89
26	1.25"	60°	$99
32	2.00"	60°	$149
40	2.00"	60°	$199

5 Element Plössl Set **$349**
Includes: 5.5, 14, 20, 32mm and alumium case

TeleXtenders Series 5000™

Magnification	Barrel Size	Price
2x	1.25"	$159
3x	1.25"	$159
5x	1.25"	$159
2x	2.00"	$229

2" Enhanced Diagonal Series 5000™

NEW

- Enhanced dielectric coatings with 99% reflectivity over the visual spectrum
- Interferometer tested
- Thermally stable Pyrex® glass
- Includes 1.25" eyepiece adapter with non-marring compression ring

$199.00

QX Wide Angle Eyepieces Series 4000™

70°
AFOV

Focal Length	Barrel Size	AFOV	Price
15mm	1.25"	70°	$79
20mm	1.25"	70°	$79
26mm	2.0"	70°	$89
30mm	2.0"	70°	$89
36mm	2.0"	70°	$99

Eyepiece & Filter Set Series 4000™

NEW

Designed and manufactured to exacting standards. Series 4000 Super Plössl eyepieces deliver 52°AFOV (44° for the SP40mm) with all of the resolution, edge-of-field sharpness and color correction demanded in the most advanced visual applications.

$299

Only $199 if purchased together with any Meade telescope.

Each Series 4000 Set Includes:

6.4mm Super Plössl	$49.00
9.7mm Super Plössl	$49.00
12.4mm Super Plössl	$49.00
15mm Super Plössl	$49.00
32mm Super Plössl	$69.00
40mm Super Plössl	$69.00
2x Barlow Lens (#126)	$47.95
Color Filter Set #1 (yellow/red/green/blue)	$49.95
Moon Filter	$16.95
Aluminum Hard Carry Case	$69.95
Total price if purchased separately	**$518**

Deep Sky Imager™ with AutoStar Suite™

DSI

DSI Pro

DSI (Color)	$299
DSI Pro (Monochrome)	$399
DSI Pro with filters	$499
DSI II (Color)	$599
DSI II Pro (Monochrome)	$599
DSI II Pro with filters	$699

more info at meade.com/dsi

Lunar Planetary Imager (LPI™)

Now $99

The LPI™ camera will have you taking pictures of the moon and planets like a pro – right out of the box with exclusive features like Meade's Drizzle Technology™.

more info at meade.com/lpi

AC Adapters

RCX400™ AC Adapter For RCX400, LX200™GPS, LX200R™, LX90™, LX90GPS™, LXD55, LXD75 telescopes	$79.95
#541 AC adapter For LX90GPS, LX90, LX10, EXT®90, EXT105, EXT125 telescopes	$49.95
#546 AC adapter For EXT®60, EXT70, EXT80, DS-2000, NG series telescopes	$19.95
#607 cigarette lighter adapter For all Meade telescopes	$25.00

Focal Reducers Series 4000™

$129.95

f/6.3 Focal Reducer
- 4-element, multi-coated
- Reduces exposure times by approximately 50%

$149.95

f/3.3 CCD Focal Reducer *
- 3-element, multi-coated
- Variable T-adapter included

* For photographic use only

Wireless AutoStar® II

Now $199

Remote control of your telescope has never offered such freedom. Just plug the Wireless AutoStar II into the handbox port of your LX200GPS, LX200R, or RCX400 telescope and wireless control of the universe is at your fingertips.

* Only for use on LX200GPS, LX200R and RCX400 telescopes.

MEADE AUTHORIZED DEALERS

TELESCOPES.COM
800-958-6040

ASTRONOMICS
800-356-6603

OPTICS PLANET
888-263-0356

OPT CORP.
800-338-9638

SCOPE CITY
800-235-3344

ADORAMA
800-223-2500

B&H PHOTO
800-329-0315

CANADA
EFSTON SCIENCE
888-396-3233

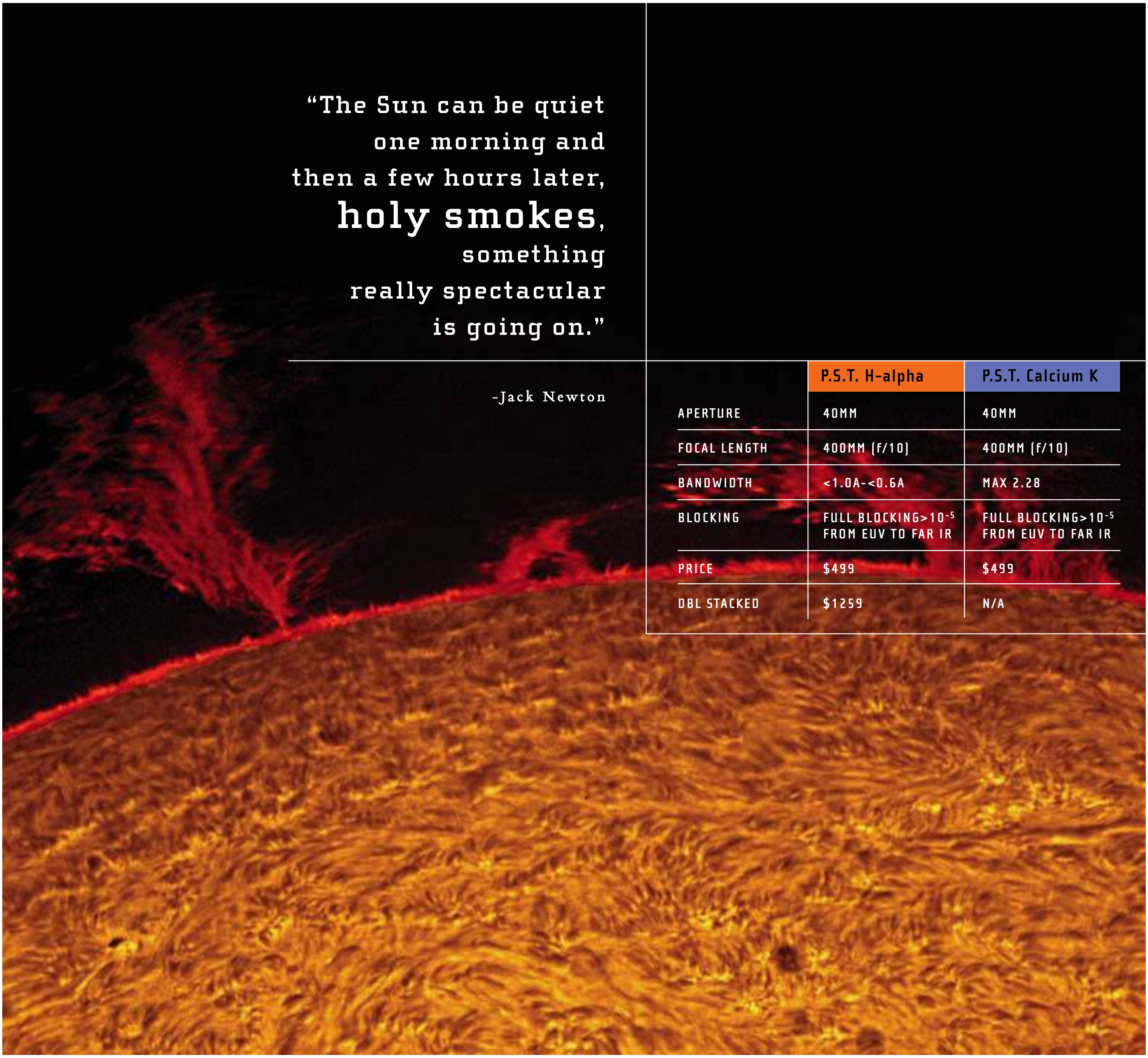
Ultra-Wedge

- Heavy-duty construction
- Ultra-smooth, fine tune adjustments
- High-precision polar alignment
- Rock solid

$499.95

* For LX90, LX200, and RCX400 series telescopes.

Copyright © 2006 Meade Instruments Corporation. Patents Pending. All rights reserved. 30-06002.



"The Sun can be quiet
one morning and
then a few hours later,
holy smokes,
something
really spectacular
is going on."

-Jack Newton

	P.S.T. H-alpha	P.S.T. Calcium K
APERTURE	40MM	40MM
FOCAL LENGTH	400MM (F/10)	400MM (F/10)
BANDWIDTH	<1.0A-<0.6A	MAX 2.28
BLOCKING	FULL BLOCKING>10^{-5} FROM EUV TO FAR IR	FULL BLOCKING>10^{-5} FROM EUV TO FAR IR
PRICE	$499	$499
DBL STACKED	$1259	N/A

Solar astronomy is filled with action. Flares erupt. Prominences appear that are four times larger than earth. Sunspots occur and rotate for days. And the entire Sun looks like a lace tablecloth with millions of thread-like filaments. Of course, all of this assumes you are witnessing these phenomena through a Coronado H-alpha (H-a) telescope. You can learn more about H-a at our website. But even at the entry level, views through the affordable PST® H-a are nothing short of breathtaking. That's why the scope recently won a Popular Science Best of What's New award. For true solar aficionados, the brand new Calcium K (CaK) PST isolates a layer of gas deep within the Sun's Chromosphere to let you see emerging flux regions and predict events long before they appear in H-a. Either way, if you love astronomy, a Coronado PST will let you enjoy your passion night and day.

CORONADO
PST

CORONADO®

PHOTOGRAPHY - JACK NEWTON

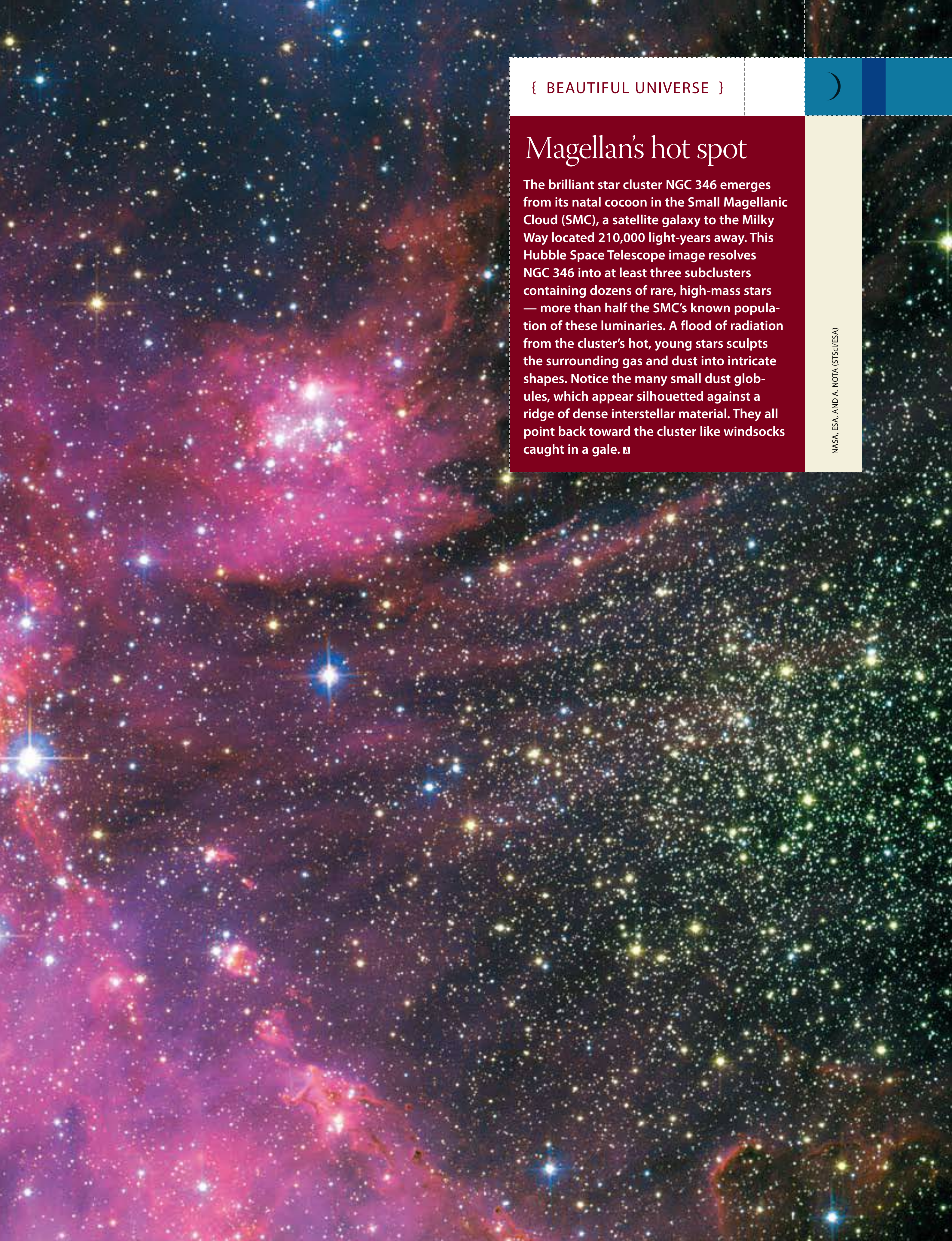
CORONADOFILTERS.COM 1.866.SUNWATCH

TELESCOPES.COM (800.958.6040) • ASTRONOMICS (800.356.6603) • OPTICS PLANET (888.263.0356)
OPT CORP. (800.338.9638) • SCOPE CITY (800.235.3344) • ADORAMA (800.223.2500)
B&H PHOTO (800.329.0315) • CANADA - EFSTON SCIENCE (888.396.3233)

30-06006

Magellan's hot spot

The brilliant star cluster NGC 346 emerges from its natal cocoon in the Small Magellanic Cloud (SMC), a satellite galaxy to the Milky Way located 210,000 light-years away. This Hubble Space Telescope image resolves NGC 346 into at least three subclusters containing dozens of rare, high-mass stars — more than half the SMC's known population of these luminaries. A flood of radiation from the cluster's hot, young stars sculpts the surrounding gas and dust into intricate shapes. Notice the many small dust globules, which appear silhouetted against a ridge of dense interstellar material. They all point back toward the cluster like windsocks caught in a gale.



NASA, ESA, AND A. NOTA (STScI/ESA)

astronomics™ . . . our 27th year.

We've been helping people choose the right telescope since 1979. We have the experience (a staff total of over 150 years of experience using and selling telescopes) to help *you* pick the telescope that fits your needs (and your budget). And, with our seven-figure inventory, we can usually ship you the right scope, right away, from the hundreds of scopes we stock.

We started ***astronomics*** over 26 years ago because we loved astronomy,

Celestron's SkyScout *tells* you about the sky while it shows you the night's sights.

$399

The **Celestron SkyScout** is an award-winning handheld non-magnifying GPS-based personal planetarium that identifies or locates more than 6,000 celestial objects visible to the unaided eye, then tells you their facts and history. Use the SkyScout by itself to learn the legends, myths, and sights of the sky. Or mount it on your telescope to let it guide you from one celestial showpiece to another.

There's a scrolling 5-line display of text and graphics. Supplied earphones let you hear the commentary so you don't have to look away from the sky to read it. Optional speakers let others hear, too.

The SkyScout transforms the night sky into a planetarium for stargazers, families, and students. It makes learning the stories of the sky – *and finding your way around the sky* – easier than ever before.

New Meade ED triplet apo refractors start at $599. Wow!

80mm ED APO package **$699**

Meade Series 5000 ED refractors use ED (Extra-low Dispersion) glass in their fully multicoated, air-spaced, triplet apochromatic optical systems. The ED glass provides extra high contrast, with no spurious color fringing around bright objects. It makes these refractors superb for wide field astrophotography, as well as exceptional for visual observing.

These are optical tubes only, with no mounts. They have adjustable lens cells, a Crayford-style focuser, dust covers, an L-bracket tripod mounting shoe, and a retractable lens shade. The package versions add a $199 retail 2" dielectric star diagonal for only $100.

80mm ED, 3.1" f/6 triplet apo	**$\$599^{00}$**
80mm ED, as above, w/2" dielectric diag	**699^{00}**
127mm ED, 5" f/7.5 triplet apo	**1799^{00}**
127mm ED, as above, w/2" dielectric diag	**1899^{00}**

21st century Celestron go-to . . . at a 1984 price.

$1399

If you fondly remember the original orange-tube Celestron C8 – the scope that made amateur astronomy affordable – the **Celestron NexStar 8i Special Edition** will bring back the good old days . . . at a low price straight out of the 1980s!

The scope has a modern anodized version of Celestron's vintage orange and black paint, a convenient go-to computer with no-guesswork *SkyAlign* technology, and the bright images of Celestron's best Starbright XLT multicoatings.

The most amazing part? This 21st century telescope is available for less than the price of a C8 from 1984 that didn't even have a computer.

Amateur astronomy has changed a lot over the past 20 years. But the value and performance of a Celestron C8 have always been standards you can rely on.

Whether red dot or bull's eye, we have a finder for you.

$3995 Telrad, including batteries

Non-magnifying red dot and bullseye finders seem to project dots and circles of red light on the dome of the sky. They make it easy to aim your telescope or to star hop from object to object.

Like the original Telrad above (we've sold thousands of these), all of our red dot finders come with batteries and bases. We also carry dozen of conventional finders, from 5 x 25mm to 12 x 80mm.

Here's a list of the non-magnifying illuminated finders that we keep in stock:

Burgess, MRF multiple reticle	**$\$69^{00}$**
Celestron, Star Pointer red dot	**29^{95}**
Rigel, QuikFinder bull's eye	**39^{95}**
TeleVue, Qwik-Point red dot	**30^{00}**
Starbeam red dot	**215^{00}**
Starbeam red dot for TeleVue only	**215^{00}**
Starbeam red dot for SCTs	**250^{00}**
Telrad, bull's eye	**39^{95}**
Vixen, red dot for Vixen scopes only	**79^{00}**

> Just wanted to drop a line to let you know how impressed I was with the whole process of ordering my telescope. The service was top notch and I received everything very quickly. I will definitely be ordering again soon.
>
> **Customer Quote of the Month #169**

No-guesswork Celestron CPC Sky Align *GPS* SCTs.

Celestron 8" f/10 CPC800

$1899

It's easy to find your way around the sky with a new **Celestron CPC**. Just point it at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet or the Moon) and the CPC will find over 45,000 fascinating deep space objects for you at the touch of a button.

You don't have to memorize a star chart to use a CPC. The scope's built-in GPS system and a few anonymous points of light in the sky are all you need.

Celestron CPC Schmidt-Cassegrains are fully equipped with all the features you need to start observing immediately.

8" **CPC800**, Starbright coatings	**$\$1899^{00}$**
8" **CPC800X**, XLT coatings	**1999^{00}**
9¼" **CPC925**, Starbright coatings	**2349^{00}**
9¼" **CPC925X**, XLT coatings	**2499^{00}**
11" **CPC1100**, Starbright coatings	**2599^{00}**
11" **CPC1100X**, XLT coatings	**2799^{00}**

A Meade Ritchey-Chrétien for only $2499? *Incroyable!*

Meade 8" f/10 LX200R Ritchey-Chrétien

$2499

freight paid

At least we think French optician Henri Chrétien would call it "incredible" if he were still alive and knew that the kind of telescope optics that he and George Ritchey designed – the kind used in the 300" Keck telescopes and the Hubble Space Telescope – were now available at prices virtually every backyard astronomer and astrophotographer can afford.

The new **Meade LX200R** telescopes combine 8" to 16" f/10 versions of the modified Ritchey-Chrétien optics used in Meade's famous RCX400 scopes with the superb mechanics of the best-selling Meade LX200GPS series. The result is true state-of-the-art telescopes at prices within reach and reason.

The 8" to14" LX200R scopes usually ship from our stock, saving you time over non-stocking dealers who must have Meade ship them to you (and if you live in California, we save you the sales tax).

Here are the *freight-paid* prices on the LX200R scopes that we ship from our stock:

8" **LX200R**	**$\$2499^{00}$**
8" **LX200R,** with UHTC optics	**2674^{00}**
10" **LX200R**	**3399^{00}**
10" **LX200R,** with UHTC optics	**3634^{00}**
12" **LX200R**	**4399^{00}**
12" **LX200R,** with UHTC optics	**4694^{00}**
14" **LX200R**	**5999^{00}**
14" **LX200R,** with UHTC optics	**6349^{00}**

Because of their weight, these 16" LX200R scopes ship to you via truck from Meade.

16" **LX200R,** without mount, w/UHTC	**$11{,}529^{00}$**
16" **LX200R,** tripod, w/UHTC	**$12{,}494^{00}$**
16" **LX200R,** altaz pier, w/UHTC	**$12{,}524^{00}$**
16" **LX200R,** eq pier, w/UHTC	**$12{,}779^{00}$**

Meade LX90 scopes *now come with GPS.*

Meade LX90 8" to 12" go-to SCTs are now available two ways – either with easy-to-use LNT (Level North Technology), or with automatic GPS. They ship from our stock, so we save you shipping time over dealers who have them drop-shipped from Meade (and if you live in California, we save you the sales tax).

Here are the *freight-paid* prices on the LX90 scopes that we ship from our stock:

8" LX90-LNT	**$\$1799^{00}$**
8" LX90-LNT, with UHTC optics	**1974^{00}**
10" LX90-LNT	**2299^{00}**
10" LX90-LNT, with UHTC optics	**2474^{00}**
12" LX90-LNT	**2999^{00}**
12" LX90-LNT, with UHTC optics	**3294^{00}**
8" LX90-GPS	**1899^{00}**
8" LX90-GPS, with UHTC optics	**2074^{00}**
10" LX90-GPS	**2499^{00}**
10" LX90-GPS, with UHTC optics	**2734^{00}**
12" LX90-GPS	**2999^{00}**
12" LX90-GPS, with UHTC optics	**3294^{00}**

Meade 8" LX90-GPS

$1899

freight paid

Level North Technology makes it easy to line up your LX90 on the sky and start observing. Simply tell your LX90-LNT your location *or zip code.* It levels its optical tube by itself, aims it North, checks the time, then moves to its two alignment stars – *all automatically!*

With the LX90-GPS models, you don't even have to tell the scope your location. A built-in GPS receiver gets that information from Earth-orbiting satellites automatically. Once your scope moves to its alignment stars, check that its red dot finder is centered on those stars (you also get an 8 x 50mm finder), and start enjoying computerized go-to observing. An LX90 makes astronomy that easy!

Want *unbiased* equipment reviews?

www.cloudynights.com

Celestron NexImage captures the solar system for $99.

The $99 **Celestron NexImage** CCD camera takes high power full color images of the Moon and planets with any telescope. It sends them to your computer to view live or print out later. The full color CCD imaging chip in the NexImage has a big 640 x 480 array of 5.4 micron pixels for sharp and clear high-resolution images.

For wider lunar panoramas, the optional $24.50 NexImage Reducer Lens will double the camera's field of view.

Celestron *SkyAlign* go-to scopes start at a low $279.

$379

80mm Celestron NexStar 80 SLT

You don't need to know the Pleiades from Polaris to find your way around the sky with a **Celestron SLT** go-to scope. With Celestron *SkyAlign* technology, just point your SLT at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet), and the SLT will find the planets and over 4,000 deep space objects for you *automatically.* A few anonymous points of light are all you need to find your way around the skies.

Celestron SLT no-guesswork go-to scopes are available in these sizes:

NexStar 60, 60mm refractor	**$\$279^{00}$**
NexStar 80, 80mm refractor	**379^{00}**
NexStar 102, 102mm refractor	**479^{00}**
NexStar 114, 114mm reflector	**399^{00}**
NexStar 130, 130mm reflector	**439^{00}**

Each has *two* eyepieces, red dot finder, motor drives, stainless steel tripod, NexStar computer, software to control the scope from your computer, and more.

astronomics™

Our 27th year of friendly service, good advice, and money-saving prices.

680 24th Avenue SW, Norman, OK 73069

Toll-Free Telephone: **(800) 422-7876** If the toll-free telephone lines are busy: **(405) 364-0858**

Toll-free from the 50 United States and Canada.

Anyone can sell you a telescope. We'll sell you the right telescope.™

not just as a business. Our sales may have grown over a thousand-fold since that first year, but we're still the same family-owned, family-run, full-line telescope dealer we were in 1979. And we still love astronomy.

astronomics. No hard sell. No guesswork. Just honest advice, the time to make sure you get the right telescope and accessories, and a good price. Call us toll free at (800) 422-7876 and find out for yourself.

It's the real deal. Dielectric diagonals starting at $69⁹⁵.

$139⁹⁵
$149⁹⁵
$69⁹⁵

These top quality **Astronomy Technologies** star diagonals increase light transmission *and* improve contrast and detail when compared with the so-so prism diagonal supplied with most new telescopes.

The **Astro-Tech** diagonals come with your choice of 96% reflectivity enhanced aluminum or very durable 99% reflectivity *46-layer* dielectric first surface mirror coatings, both on a 1/10th wave 10mm thick BK7 optical glass substrate. Each uses a non-marring compression ring to hold eyepieces in place. The 2" diagonals come with a 1.25" eyepiece adapter with a compression ring eyepiece holder at no extra charge. The 2" diagonals are available with your choice of a standard 2" nosepiece for use with a refractor or with a threaded ring to connect to a Schmidt-Cassegrain rear cell.

Here are the prices of the five high quality **Astro-Tech** star diagonals we keep in stock:

1.25" dielectric	**$69.95**
2" enhanced aluminum	**79.95**
2" dielectric	**89.95**
2" SCT enhanced aluminum	**139.95**
2" SCT dielectric	**149.95**

Dual speed focusing = more bang for your buck.

Astro-Tech AT80 80mm optical tube

The **Astronomy Technologies AT80** has all the bells and whistles you expect from an 80mm achromatic refractor, plus a few you wouldn't expect at the price.

It has a multicoated 80mm f/6 doublet optical system that noted refractor designer Thomas M. Back says is "a high quality achromat . . . excellent multicoatings . . . reflectivity was very low, noticeably better than any other standard achromat I've seen . . . wavefront was well above average. No coma, astigmatism, zones, and the spherical correction was corrected well beyond the diffraction limit. Contrast was also very high, making this lens excellent for not only wide field views, but lunar and planetary work."

The **Astro-Tech AT80** has dual speed focusing – one knob for standard speed focusing, the other for ultra-fine focusing at an 11:1 ratio. It comes with a fully rotatable 2" Crayford-style focuser and 1.25" eyepiece adapter, both with compression ring eyepiece holders; retractable self-storing lens shade; dust caps; and fitted soft carrying case. Use it as a super finder or photoguide for your main scope or as an optically excellent second scope for spur-of-the-moment astronomy, travel, or birding. Available in white and Meade blue.

Celestron Dobs are nifty, inexpensive, *and in stock.*

8" f/6 StarHopper

Celestron StarHopper Dobsonians use roller bearings for smooth hitch-free motion at the touch of a finger.

The 6" StarHopper comes with a 6 x 30mm finder, a 1.25" metal rack and pinion focuser, and a 25mm 1.25" Plössl eyepiece.

8", 10", and 12" StarHoppers have a big 9 x 50mm finder, 2" metal rack and pinion focuser (with a 1.25" eyepiece adapter), and a 32mm E-Lux 2" eyepiece. The 10" and 12" scopes have a battery-operated fan for cooling their primary mirrors. All scopes have fast cool-down metal tubes and BK7 optical glass mirrors, and all are in stock for immediate shipment.

Here are the prices for the fully-equipped Celestron StarHopper Dobsonians we stock.

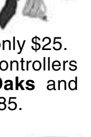
6" f/8 StarHopper	**$249⁰⁰**	+ $59 freight
8" f/6 StarHopper	**339⁰⁰**	+ $69 freight
10" f/5 StarHopper	**499⁰⁰**	+ $79 freight
12" f/5 StarHopper	**849⁰⁰**	+ $129 freight

Do it to dew before dew does it to you.

Nasty old dew can do in your observing or astrophotography. Instead of mopping off your optics after dew has formed, it's easier to keep dew from appearing in the first place. We carry 67 different dew shields to slow the formation of dew, giving you more time to observe. We also carry 56 dew heater straps and controllers to prevent the formation of dew entirely, plus 16 heated dew shields.

We stock flexible, easy-to-store, roll-up plastic dew shields from **Astrozap** for most telescopes starting at $24.95; hard plastic ETX dew shields from **Meade** starting at $19.95; and a hard plastic CPC dew shield from **Celestron** at $42.95. We also carry **Astrozap** metal dew shields for most scopes, starting at $39.95, that have a baked-on finish to match the color of your scope's optical tube. Metal **Meade** dew shields for your LX90 or LX200 start at $140.

Heated flexible dew shields from **Astrozap** start at only $49.95.



We carry dew heater straps from **Kendrick**, **Astrozap**, and **Thousand Oaks** for all sizes and types of scopes at prices starting at only $25.

And dew heater controllers from **Thousand Oaks** and **Kendrick** start at $85.

72° for only $1.08 per degree. *Nice.*

The 9, 15, and 20mm 1.25" Swan eyepieces from **William Optics** all have a very wide 72° field for a mere $78 each. The 25, 33, and 40mm 2" Swans at only $118 each also have a wide 72° field (70° on the 40mm).

We actually stock TeleVue. Does your dealer?

NP-101 $3685
TV-85 $2150

If it's from TeleVue, chances are good we have it in stock. Others say they carry TeleVue, *but we actually keep TeleVue in stock.* Lots of it.

Here are a few of the TeleVue scopes we stock for immediate shipment. These are optical tubes only, with dust covers and carrying case.

TV-60, 2.4" f/6 apo	**$825⁰⁰**
TV-76, 3" f/6.3 apo	**1320⁰⁰**
TV-85, 3.35" f/7 apo	**1750⁰⁰**
TV-102, 4" f/8.6 apo	**2250⁰⁰**

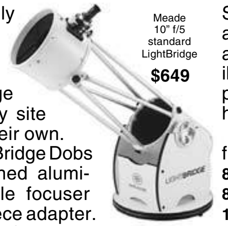
The following scope packages (for use on your own mount) with a star diagonal, Plössl eyepiece, tube ring, dust covers, and case, are also in stock.

TV-76, 3" f/6.3 apo	**$1725⁰⁰**
TV-85, 3.35" f/7 apo	**2150⁰⁰**
TV-102, 4" f/8.6 apo	**2685⁰⁰**
Renaissance, 4" f/8.6 brass	**3250⁰⁰**
NP-101, 4" f/5.4 Petzval apo	**3685⁰⁰**

As for TeleVue accessories, we have them all in stock. Need a Gibraltar, TelePod, or Panoramic altazimuth mount? A Sky Tour computer? Need a Nagler, Radian, Panoptic, or Plössl eyepiece? Need a Powermate image amplifier or a Barlow lens; an Everbrite 99% reflectivity star diagonal; a light pollution filter; one of the Dioptrx astigmatism-correcting lens? A BinoVue? No matter. If it's from TeleVue, chances are good we have it in stock. For example, here are a few of the eyepieces from TeleVue that we can ship today.

8, 11, or 15mm 1.25" Plössl	**$85⁰⁰**
32 or 40mm 1.25" Plössl	**115⁰⁰**
3, 4, 5, 6, 8, 10, 12, 14, or 18mm 1.25" Radian	**250⁰⁰**
2.5, 3.5, 5, 7, 9, 11, or 13mm 1.25" Nagler Type 6	**290⁰⁰**

Outer space is infinite. Your car's back seat is not.



Meade 10" f/5 standard LightBridge

Meade LightBridge Dobsonians use a truss-tube design that lets even the big 12" models break down into a few small packages that easily fit into a compact car. One person can transport a Meade LightBridge Dob to a dark sky site and set it up on their own.

All Meade LightBridge Dobs have a 2" machined aluminum Crayford-style focuser with a 1.25" eyepiece adapter. A battery-operated fan on the metal primary mirror cell assures fast cooling of the diffraction-limited BK7 optical glass mirror. No tools are needed to assemble and break down the scope in the field.

Standard models have a 1.25" 26mm Super Plössl eyepiece, a red dot finder, and Teflon bearings. Deluxe models have a 2" 26mm 70° field QX eyepiece, an illuminated finder with four different reticle patterns, and roller bearings for smooth hitch-free motion at the touch of a finger.

The prices below include the shipping from the Meade factory.

8" f/6 standard LightBridge	**$469⁰⁰**
8" f/6 deluxe LightBridge	**569⁰⁰**
10" f/5 standard LightBridge	**649⁰⁰**
10" f/5 deluxe LightBridge	**749⁰⁰**
12" f/5 standard LightBridge	**949⁰⁰**
12" f/5 deluxe LightBridge	**1049⁰⁰**

TMB-designed 60° field planetary eyepieces, $99.

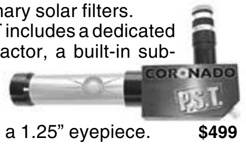
Famed refractor designer Thomas M. Back created these **Burgess Optical** 1.25" 4, 6, and 9mm planetary eyepieces to match the image quality of his $25,000 apo refractors. That they do it for only $99 each is amazing!

The new Meade Deep Sky Imager *II,* $599.

The new **Meade Deep Sky Imager II** has a larger CCD chip than the original Deep Sky Imager (which is still available at $299). The DSI II has greater sensitivity, higher resolution (752 x 582 pixels), and dramatically lower thermal noise that lets you take hour-long deep space exposures without having to cool the camera.

While the new DSI II works with any scope, you can use its NASA-developed "Drizzle" software with Meade Autostar-equipped ETX, LX90, LX200, or RCX400 telescopes for long exposures without the need for an equatorial wedge.

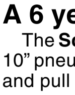
Serious solar observing for the price of an eyepiece!



For no more than cost of a premium eyepiece, the sub-Ångstrom hydrogen alpha filter in the **Coronado PST** (Personal Solar Telescope) lets you see the ever-changing drama of solar flares and prominences growing and subsiding before your eyes. It doesn't just show you sunspots, as do ordinary solar filters.

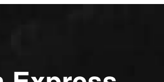
The PST includes a dedicated 60mm refractor, a built-in sub-Ångstrom solar filter, a safe Sun finder, and a 1.25" eyepiece. **$499**

Telegizmos protects your scope day and night.



A **Telegizmos** scope cover protects your scope from sun and dew. NASA-developed to insulate spacecraft, this aluminized cover is strong, light, and more durable than Mylar. Prices start at only $29.

A 6 year-old can move your telescope.



The **ScopeBuggy** scope transporter's 10" pneumatic tires, pivoting front wheel, and pull handle are so efficient that one customer's 6 year-old can move his 14" SCT all by herself. **$265**

24-Hour FAX line: (405) 447-3337 Our e-mail address: questions@astronomics.com

Our award-winning Internet site: www.astronomics.com Mastercard, Visa, Discover, American Express.

PHONE HOURS: 8 to 9 CST Monday thru Friday, Saturday 12 to 5. STORE HOURS: 9 to 5 Monday thru Friday, Saturday by appointment.

U. S. sales *only* – except for Meade and Takahashi which are also available for sale to Canada. Prices, special offers, and specifications are current as of 1/10/06, but are subject to change. $7.95 minimum freight. All returns less freight. Restocking fees apply to returns for credit and to merchandise returned used or damaged. **We meet or beat any advertised price.**

Price match fine print: competitor's price must be verifiable and available nationally; chain store, close-out, and going-out-of-business prices are excluded; no retroactive price matching; a package price must be from a single competitor.

Strings untied

I would like to thank Bob Berman for his realistic perspective on string theory in "Tangled up in strings" (January 2006). I became interested in science as string theory was gaining popularity, and, like many of my peers, I became enamored of it. Fortunately, I escaped the fervor when my father, a particle physicist, explained the enormous flaws in string theory. I hope Peter Woit's book gets as much attention as it deserves. — **KATHERINE McCARTHY,** HEDGESVILLE, WEST VIRGINIA

Peter Woit holds a Ph.D. in physics, is a lecturer at Columbia University, and, as Bob Berman describes, is "an active anti-ST crusader." His book, Not Even Wrong: The Failure of String Theory & the Continuing Challenge to Unify the Laws of Physics, *will be available in the United States in fall 2006.*
— ***ASTRONOMY* EDITORS**

Thank you for Bob Berman's article on string theory. His description of string-theory enthusiasts' quest for the grand unified theory makes me want to blurt out a word from astronomy's past — epicycles!

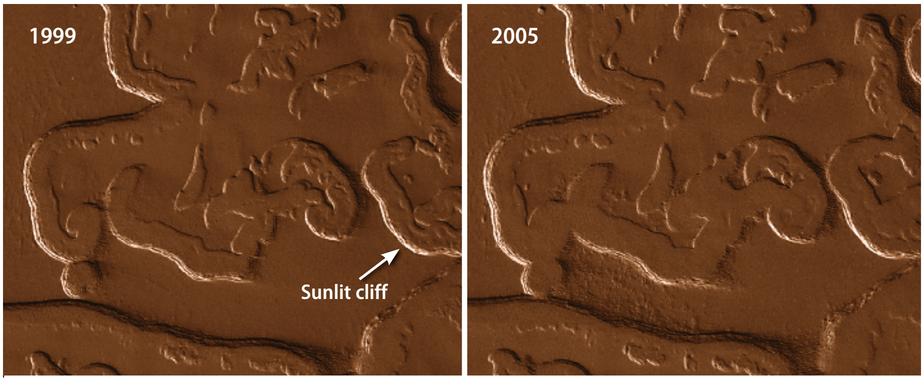
Who can forget the mathematical contortions of the Ptolemaic cosmic-model crowd? Their vision of planetary bodies circling Earth in a dizzying trajectory of wheels within wheels, epicyclical motion within epicyclical motion, was a gallant attempt to make the observable universe behave on paper as it *should*. It was all heroic brain work, and, of course, all dead wrong.

Will much of our modern speculative physics and astrophysics like string theory end up in the same basket?
— **JULIUS WROBLEWSKI,** VANCOUVER, BRITISH COLUMBIA

Global warming heats up Mars

Noting the dramatic shrinking of dry-ice mesas at Mars' south pole in the News story "Martian features disappear" (January 2006) as well as your comment about a warming spell, I wonder if this means Martians are causing global warming by the use of fossil fuels.

It sounds ridiculous, but that is the conclusion many have jumped to about Earth. While I believe man has contributed a little to Earth's warming, your Mars item suggests natural cycles contribute significantly to a planet's warming. — **BILL JAMIESON,** MENDOTA, ILLINOIS



MESAS OF DRY ICE at the martian south pole have been retreating by about 10 feet (3m) per Mars year since Mars Global Surveyor began imaging them in 1999. NASA/JPL/MSSS

On strings and Mars' warming

After reading Bob Berman's January column, it's safe to say cosmic strings may have been woven from the same fabulous material as the emperor's new clothes.

And the January News article about Mars' shrinking mesas offered the line "mesas of dry ice at the martian south pole have been retreating." This obviously means the little green men should ratify the Kyoto Protocol before it's too late. — **MARK D. TASCH,** ZIONSVILLE, INDIANA

Moore respect

Tom Stoppard's negative assessment of Sir Patrick Moore's contributions to the astronomy world (Letters, January 2006) is perverse. Stoppard's suggestion that Moore's technical discussions "have reduced the field to one of telescopes and trinkets" is just plain silly.

Further, to say that Stephen Hawking has to a greater extent "broadened the minds" of what Stoppard calls the two men's respective young fan clubs also is unjustified. Over a remarkable period, Moore has educated, entertained, and inspired people of all ages. As an astronomy popularizer, he is in a class by himself.
— **RON WESTMAAS,** SOMERSET, ENGLAND

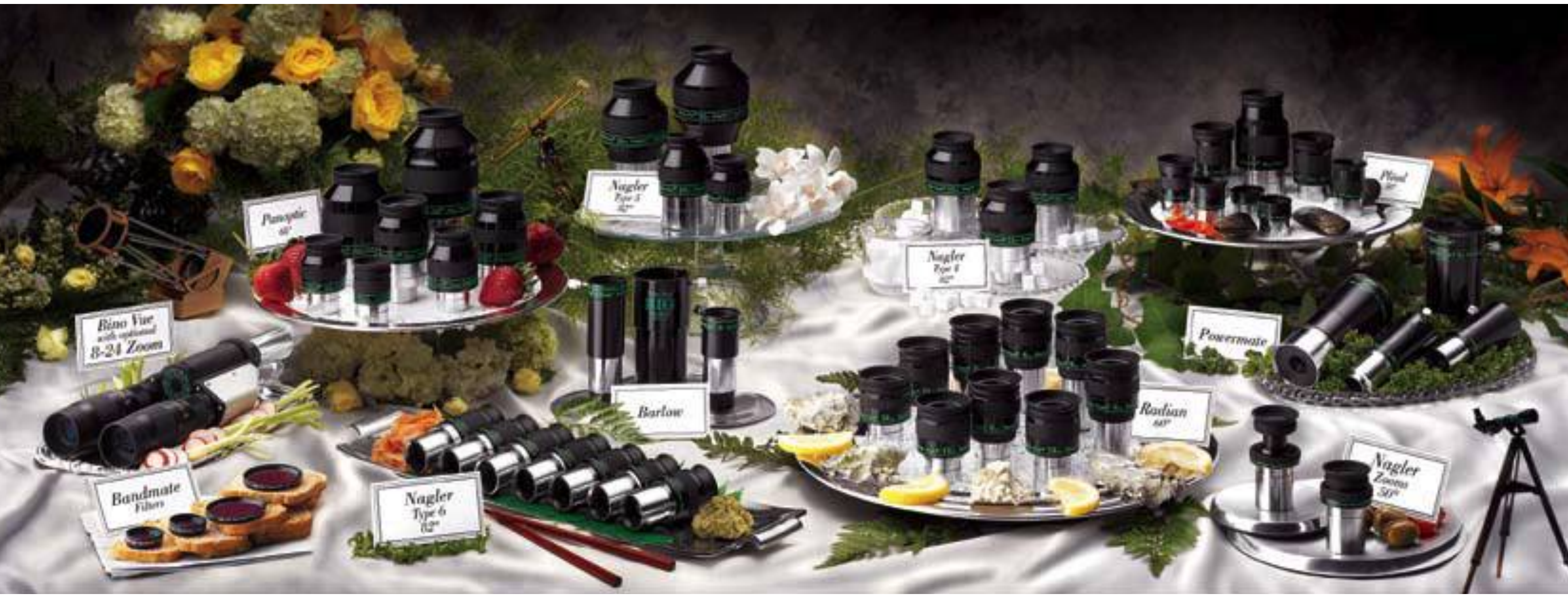
Correction

Bill and Sally Fletcher took the image of Orion the Hunter on page 79 of the January 2006 *Astronomy*.

We welcome your comments. Send letters to Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Tele Vue Eyepieces...

The Ultimate Condiment for All Telescopes...Even Our Own



Nagler 82°
The jaw-dropping 82° "spacewalk" experience in new technology designs.
- •Type 4: Longer eye-relief and adjustable eyeguard.
- •Type 5: 31, 26mm for wider true fields, 20, 16mm lighter and smaller than Type 4.
- •Type 6: Higher power models with comfortable 12mm eye-relief. Uniform compact sizes, great for Bino Vue.

Panoptic 68°
Tack-sharp! Great alternative to Naglers. The 41mm and 24mm models deliver largest true fields in their barrel sizes. 24mm and 19mm stunning with Bino Vue.

Radian 60°
20mm of eye-relief in all models. Adjustable eyeguard for use with or without eyeglasses. Perfect for Bino Vue and afocal imaging!

Plössl 50°
Patented design using high index glasses, and tuned coatings make these sharper than other simple designs. You don't have to pay a premium for top-rated premium eyepieces.

Nagler Zooms 50°
2—4 and 3—6mm give planetary eyepieces a new "twist." Tune power to the most sky conditions will allow. High contrast 5-element design with full field sharpness and constant 10mm eye-relief make Nagler Zooms far superior to other "planetary" eyepieces of equivalent focal lengths.

Introducing DIOPTRX™
DIOPTRX™ lenses attach to 21 types of Tele Vue eyepieces to correct your eyesight astigmatism. Ten DIOPTRX™ models available to match your exact prescription.

Made in
U.S.A.
Since 1980

Tele Vue-60
60mm APO, f/6.0
Use as a day/night "take me everywhere" scope for birding and astronomy. Only 10" long.

Tele Vue-76
76mm APO, f/6.3
"tack-sharp at all magnifications with no glare or false colors." — Astronomy

Tele Vue-85
85mm APO, f/7.0
"Redefining the standard of excellence for small-aperture refractors." — S&T

Tele Vue-102
102mm APO, f/8.6
"superb mechanical craftsmanship... optical near perfection." — S&T

Tele Vue-NP101
101mm 4-element APO, f/5.4
"Optics don't get any better than this." — Backyard Astronomer's Guide

Tele Vue-NP127
127mm 4-element APO, f/5.2
Big brother of the NP101. "There isn't a better 5" refractor built." — C.J. (customer)

TeleVue®
Visionary

Tele Vue Optics, Inc., 32 Elkay Drive, Chester, New York 10918 845.469.4551 www.TeleVue.com

{ BOB BERMAN'S STRANGE UNIVERSE }

BY BOB BERMAN

Center of the action

Until the 20th century, astronomers were strictly outsiders. They ignored star and planet interiors. They had to. Telescopes showed only the tops of things. Scientists knew that a ball's "inside" constitutes virtually all its mass, and the limitation was frustrating. Basic questions went unanswered. For example, what lies below the dazzling solar surface? How can the Sun keep shining when even the highest-quality Sun-size lump of coal would burn itself out in 2,000 years? Observers suspected that fascinating, critical processes — and maybe life itself — might not hang out where it's convenient for us to view — like on surfaces. Of course, this frustration began long before the telescope.

When ancient Greeks figured out Earth's a sphere, a new issue arose. Every ball has an "inside." Well, what's inside Earth?

Deep caves give the impression that Earth's interior is chilly. Anyone who has a basement knows a thermometer reads a constant 55° Fahrenheit (13° Celsius) all year just a few feet down. Because of this simple observation, the Ancients suspected Earth has a cool interior.

But volcanoes and hot springs provide counterexamples. These days, deep mines provide some answers. After the cool rocks of the first few dozen feet below ground, temperatures start to climb by 1° F for every 100–200 feet (30–60 meters) of depth. Today's deepest working mine, a gold mine in South Africa at 12,500 feet (3,800m), roasts at 131° F (55° C). Experimental borings drill even deeper, to nearly 40,000 feet (12,200m). That's still just 1⁄500 of the way to Earth's center.

Just last year, researchers confirmed Earth's inner core — a solid ball the size of Pluto (about 1,500 miles [2,400 kilometers] wide) — rotates faster than the rest of the world, as if there's a planet within our planet. Could there be an empty chamber there where a person would float weightless? Gravity is indeed zero at Earth's center, but the location suffers the pressure of 4,000 miles (6,400 km) of metal and rock crushing down from all directions.

Earth's liquid-metal core, swishing around that inner solid-iron core, is electrically conductive and creates our magnetic field. This field shields us from solar and cosmic radiation. Some of the bad stuff leaks through anyway, yielding a steady rate of biological mutations that alters Earth's animals over time. By comparison, look next door: The martian core froze up, destroying its magnetic field. That's one reason land is so cheap there.

> The martian core froze up, destroying its magnetic field. That's one reason land is so cheap there.

Earth's center bubbles at a fierce 8,500° F (4,700° C), thanks mostly to the decay of radioactive materials. Standing barefoot, you feel a bit of this heat percolating from deep below. But we get 5,000 times more warmth from the Sun above than from the ground below. On other worlds, the story is reversed. Jupiter and Saturn get twice as much heat from their own interiors as they do from the Sun. Because life needs energy, the prospects for creatures living "down below" on various worlds is now taken seriously. After all, life exists hundreds of feet below Earth's surface in places forever deprived of even secondary solar energy. Seemingly lifeless worlds might teem with underground biology, and the standard sci-fi image of aliens in surface cities may be as wrong as it is unimaginative.

Nucleosynthesis in stars, too, occurs out of sight. The solar surface is merely where we view the energy-release. It isn't remotely hot enough for fusion. That emerging inside-stuff is mostly photons of friendly visible light. But deep within, the power starts out as brutal gamma rays, whose photons fortunately stretch like taffy during countless encounters along their million-year journey to the Sun's surface.

It's worse elsewhere. Most of Orion's stars have higher core pressures that generate far more ultraviolet energy. Extraterrestrials on nearby planets would need sunscreen by the barrel.

Even within the same star, things change. The Sun's mutating magnetic field forms at a region called the tachocline — 7⁄10 of the way from the Sun's center to its surface — and guides solar-particle emissions. This boundary between the radiative core, which rotates like a solid ball, and its convective zone, the outer one-third with regions of differential rotation, is a hot new area of study.

The European Space Agency's Solar and Heliospheric Observatory — commonly known as SOHO — rests nearly a million miles sunward of Earth and investigates solar acoustical patterns, among other things. SOHO studies the Sun's interior by monitoring its low-frequency oscillations.

Backyard starwatchers lack such sophisticated instruments. As we gaze into the April sky, those dots of light barely hint at their true stories — each a tale that begins at the middle.

LUMICON The World's Best Filters & Astronomical Accessories

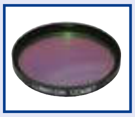
PREMIUM QUALITY FILTERS

THE DEEP SKY FILTER

The BEST light pollution filter on the market today! Perfect for visual and photographic use.

1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

THE COMET FILTER



Increases contrast and reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent.

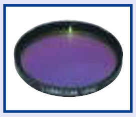
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

THE MINUS VIOLET FILTER

Produce pinpoint stars and greatly improve imaging by reducing chromatic aberration in lens systems.

1.25" - $59.95 • 2" - $79.95
58mm - $89.95 • 72mm - $99.95

THE ULTRA HIGH CONTRAST FILTER



The ULTIMATE dark sky nebula filter. Reveals the faintest of objects under both light polluted and dark skies.

1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

THE HYDROGEN-BETA FILTER

View extremely faint objects such as the Horsehead and California Nebulae. Ideal for use with 8" and larger telescopes.

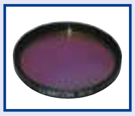
1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

POLARIZING FILTERS

Reduce glare and increase contrast on the moon and planets, as well as daytime objects. Also available in variable polarizing designs.

Single Polarizer 1.25" - $29.95 • 2" - $39.95
Variable Polarizer 1.25" - $39.95 • 2" - $49.95

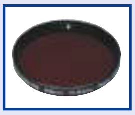
THE OXYGEN III FILTER



Legendary performance allowing near photographic views of diffuse, planetary and extremely faint nebulae.

1.25" - $99.95 • 2" - $199.95
Cassegrain Rear Cell - $199.95

THE NIGHT SKY HYDROGEN-ALPHA FILTER



A powerful photographic aid in overcoming light pollution during astrophotography of faint emission nebulae.

1.25"/2"/58mm/72mm/77mm/82mm sizes available starting from $79.95.

LUNAR AND PLANETARY FILTERS

For increased contrast on lunar and planetary detail. Optimized for both visual and photographic applications. Visit www.lumicon.com for uses.

1.25" - $19.95 • 2" - $29.95

MULTIPLE FILTER SELECTORS

Switch back-and-forth between filters without having to thread and unthread them from your eyepieces or diagonal. Leaving one of the slots open lets you compare views with and without your LUMICON filters. Made from solid aircraft aluminum. *(Filters Sold Separately)*

1.25" - $129.95 • 2" - $169.95 « **NEW**
T-Thread Adapter for 2" - $24.95

UNIVERSAL LASER POINTER BRACKET

Now you can accurately point your telescope to the stars without sacrificing comfort! Designed to work with most red and green laser pointers and easily attaches to your telescope with supplied mounting hardware. Made from solid aircraft aluminum. *(Laser Pointer not Included)*

$39.95 « **NEW**

DIAGONALS

1.25" FULLY MULTI-COATED PRISM DIAGONAL

Quality replacement for standard 1.25" diagonals - $49.95

1.25" 90° CORRECT IMAGE DIAGONAL

Displays star-field in a natural orientation at a 90° angle for easy and comfortable navigation - $69.95 « **NEW**

2" FULLY MULTI-COATED MIRROR DIAGONAL

High quality 2" mirror diagonal. Includes 1.25" reducing adapter and compression rings - $99.95 « **NEW**

ENHANCED MIRROR DIAGONALS

A premium quality mirror diagonal with 96 - 97 percent light reflectivity, 1/10 wave precision polished optics and double pass collimation testing. 1.25"- $99.95 • 2"- $189.95

LUMIBRITE MIRROR DIAGONALS

A premium quality mirror diagonal with over 98 percent light reflectivity, 1/10 wave precision polished optics and double pass collimation testing. 1.25" - $149.95 • 2" - $239.95

SUPER FINDER SYSTEMS

Shown in both straight through and right angle mode

The highest quality finderscopes available today! The newly redesigned LUMICON Super Finders feature exceptionally sharp optics, high contrast views and easy to use functionality. LUMICON Super Finders are designed to switch conveniently from straight through to right angle in seconds. Includes a quality 25mm Kellner Crosshair Eyepiece with a 90° Correct Image Diagonal for hassle free navigation in the sky.

The LUMICON 80mm Super Finder also doubles as a premium quality rich field refractor, yielding superb views of the moon, planets, star clusters, bright galaxies and daytime images. Use it with the optional Image Visor and reduce glare while increasing contrast and resolution on lunar and terrestrial views. 80mm Super Finder made from Solid Aircraft Aluminum with a durable Black Anodized finish.

50mm Super Finder System - $199.95
80mm Super Finder System - $299.95

80mm Super Finder Now Includes Custom Fit Carrying Case!

FINDERSCOPE ACCESSORIES

50mm Super Finder Body - $129.95
80mm Super Finder Body - $219.95
80mm Image Visor - $24.95
2X Fully Coated Barlow Lens - $39.95
50mm Universal Dovetail Finderscope Bracket - $49.95
80mm Universal Dovetail Finderscope Bracket - $59.95
Universal Dovetail Bracket Spare Base - $14.95
Universal Dovetail Bracket Tripod Mounting Base - $19.95

UTILITY TRAY SYSTEM

Lumicon Utility Tray System

Made from solid aircraft aluminum, the LUMICON Utility Tray System provides a safe method for attaching your Meade LX200 or LX90 telescope to its tripod and helps organize all your accessories in a secure and convenient manner. Includes a removable Adapter Plate designed to hold everything from your laptop to large star charts. Adapter Plate swivels 230° around the telescope to allow for unobstructed viewing through the telescope in any position. Utility Tray includes built in handle and bubble level for easy set up, break down and transportation. Features sturdy construction and a durable black powder-coated finish. Utility Tray and Adapter Plate can be purchased separately.

Features:

- Guide Pins for Safe Mounting of Telescope
- Bubble Level for Accurate Telescope Set Up
- Built in Handle for Easy Transportation
- Six 1.25" Eyepiece Holders
- Three 2" Eyepiece Holders - Designed for Large Model Eyepieces
- A 6" x 11" Table for Star Charts, Note-Pads and Other Accessories
- A 12" x 15" Adapter Plate that Swivels 230°
- Reversible Design for Custom Fit and Feel

Utility Tray System - $199.95
Utility Tray - $119.95
Adapter Plate - $99.95

TO ORDER please call us or visit our web site for a complete list of Authorized Lumicon Dealers worldwide.

Prices do not include shipping and handling or state taxes where applicable.

LUMICON INTERNATIONAL
750 Easy Street, Simi Valley, CA 93065
805/520-0047 • 800/420-0255
www.lumicon.com

BY GLENN CHAPLE

Diverse interests

Go, Red Sox! It's April at last, and that means it's the start of baseball season. My cheer isn't just for the Boston Red Sox, although I've counted myself among the Fenway Faithful since the early 1960s. It's also for the Leominster Red Sox, a team in the Central Massachusetts Over-40 Baseball League. For the past few summers, I've played outfield for these Sox.

Like many amateur astronomers, I don't limit my interests to things cosmic. I'm an avid angler, runner (mostly 5-kilometer events), and baseball fanatic — fantasy and the "real deal." Having alternative hobbies has definite benefits. Weather that's bad for astronomy (clouds and rain) is usually favorable for fishing. Besides, I've learned that you can get too involved in one hobby and suffer from "burnout." By diversifying my interests, I maintain an unwavering passion for astronomy.

Last month, we looked at the Cheshire-cat Moon — that luminous "grinning" Moon that greets our eyes during its crescent phase. After sunset April 1, the Cheshire cat eats the stars! Honestly, this isn't an April Fool's joke. That evening, the Moon will pass in front of the Pleiades cluster (M45) and periodically hide stars from view. This event favors observers in eastern parts of the United States and Canada. If you live outside these areas, you can still enjoy the beautiful sight of a thin crescent Moon close to this bright cluster.

Whenever the Moon passes in front of a star (an event called an occultation), it's an interesting sight to behold. In the final seconds before immersion (the star's disappearance behind the Moon), the Moon appears motionless as the star slowly "crashes" into it. Because the Moon has no atmosphere, and the star is essentially a point source of light, the star blinks out of view suddenly.

The moment of emersion (the star's reappearance) is hard to capture. Because the Moon hides the star, you never know where or when it will reappear.

When viewing an occultation, I stare for extended intervals around the predicted time of emersion so I won't miss anything. The tactic often backfires, because my eyes soon get tired and dry, which forces me to close them for a second or 2. One extended blink and — oops! — the star has already reappeared. Fortunately, Pleiades occultations offer more than one chance to witness an immersion or emersion.

For information on the visibility of the Moon-Pleiades encounter, read "High Moon" by Martin Ratcliffe on page 78 or turn to "The sky this month" on page 52 — coauthored by Martin Ratcliffe.

Post your club events at www.astronomy.com/asy/community/events. Also, visit www.astronomy.com/astronomyday to see how *Astronomy* magazine celebrates Astronomy Day.

ASTRONOMY DAY lets enthusiasts share their hobby with the community.

COURTESY NEW MEXICO MUSEUM OF SPACE HISTORY

Celebrate astronomy

Happy Astronomy Day! I realize Astronomy Day isn't scheduled until Saturday, May 6, but like any major holiday, we need time to prepare. Astronomy Day gives enthusiasts an excuse to promote their hobby by reaching out to the public via displays and demonstrations in local shopping malls and through public star parties.

In 1973, Astronomy Day began as a single event in California. Now, many astronomy clubs host Astronomy Day activities. In fact, the celebration isn't limited to a single day. This year, May 1–7 has been designated Astronomy Week.

Astronomy Day's growing success testifies to the importance of astronomy clubs. In addition to the social and information-sharing value of these organizations, astronomy clubs provide a valuable outreach service to the local community. If you're a member of an astronomy club, Astronomy Day gives you the opportunity to share this wonderful hobby with others — like that angler, runner, or baseball fanatic who might benefit from another hobby. If you are that person, get involved with your local Astronomy Day activities.

Check Astronomy.com for listings of astronomy clubs and upcoming Astronomy Day events. Notice to astronomy club members: If your club and/or Astronomy Day activities don't appear on our lists, take a few minutes to announce your club's event to *Astronomy* readers.

Gotta go. I'm running a 5K road race this afternoon. On the way home, I'll probably stop by the local fishin' hole to make a few casts. Then it's off to the batting cage to get my timing down. And once it's dark outside, you know where I'll be!

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com.

Next month: more Astronomy Day fun, plus we address a burning question, is it a half Moon or quarter Moon? Clear skies.

ORION® OrionTelescopes.com

Introducing

Sirius™ EQ-G GoTo Telescopes

Featuring the sturdiest, most-accurate GoTo equatorial mount for the price.

ORION
Sirius
EQ-G
SkyScan

Orion Sirius™ 8 EQ-G Schmidt-Cassegrain
$1,899.95

New!

Also available at OrionTelescopes.com
- Sirius 8 EQ-G Reflector
- Sirius 80ED EQ-G Apo Refractor
- Sirius 100ED EQ-G Apo Refractor
- Sirius 150 EQ-G Mak-Cassegrain
- Sirius 9.25 EQ-G Schmidt-Cassegrain

New!

Take awesome deep-space shots with our cool(ed) new imager.

Orion StarShoot™ Deep Space CCD Color Imager
$399.95

No tedious truss tubes. Just solid, easy, portable, and computerized.

SkyQuest™ IntelliScope® Dobsonians
From $489.95 *with Computerized Object Locator*

See why two-eyed touring is twice the fun.

Explorer™ 25x100 Astro Binocular
$349.95

ORION
ACCESSORY SALE!

FREE COLOR CATALOG!
Call toll-free
(800) 447-1001
or request it online.

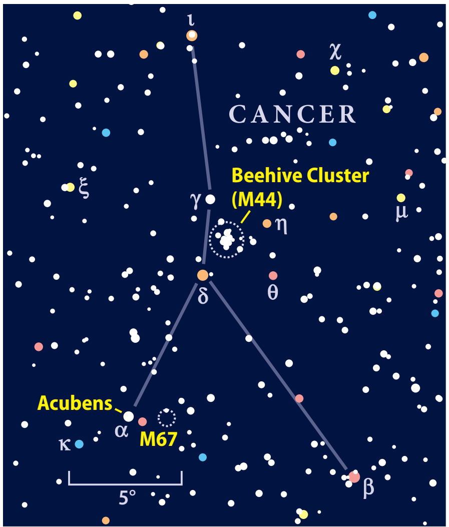
ORION Our 31st YEAR
TELESCOPES & BINOCULARS
OrionTelescopes.com
Everything for the Amateur Astronomer — Delivered Direct

IMAGINOVA

BY PHIL HARRINGTON

Two crabby clusters

If I asked you to name your favorite springtime constellation, odds are you wouldn't mention Cancer the Crab. After all, Cancer isn't much to look at, and just finding it is difficult enough — its brightest stars shine at 4th magnitude. That makes this one tough crab to catch.



USE THIS FINDER CHART to examine Cancer the Crab's insides. *ASTRONOMY*: ROEN KELLY

This year, however, a celestial interloper points the way. Saturn has been passing through **Cancer** since last year, dancing back and forth and slowly completing a retrograde loop through the Crab's trapezoidal body. Aim your binoculars toward the ringed planet this month, and you'll find Cancer's four-star shelled body to its east.

Look inside the Crab's body with your binoculars, and you'll notice it frames a swarm of fainter stars — the Beehive Cluster (**M44**). One of history's first published deep-sky observers, the Greek philosopher Aratos, discovered this cluster in 260 B.C. He described it in his poem *Phainomaina* (Heavenly phenomena) as "a little mist." Since then, countless generations of night-sky fanatics have enjoyed M44.

Whenever I look at the Beehive through my 10x50 binoculars, I see the cluster shaped like a right triangle. Of the 36 cluster stars I can count, most shine between magnitudes 7 and 9. Many form interesting pairs or patterns.

For instance — maybe because it's the start of baseball season — I see M44's five brightest stars grouped as a home plate just south of the cluster's center. A closer look at the star marking the plate's pointy tip reveals it as a triangle of stars. Multiple-star fans know this group as Burnham 584. Before you try to spot the three stars, brace your binoculars. A second conspicuous pairing of stars also stands out just north of the cluster's center.

Saturn passed M44 last September, just skirting the cluster's southern edge. As autumn faded into winter, Saturn continued its slow, easterly motion away from the Beehive. But then, Earth passed Saturn during our planet's annual trip around the Sun.

As Earth passed the ringed planet, Saturn appeared to slow down in our sky and reverse its easterly motion. It passed just south of M44 again 2 months ago, when the planet shone brightly as the hive's queen bee. As April opens, Saturn lies west of the cluster once again.

During the next few weeks, the retrograde illusion (when an object appears to move east-west across the sky) will cancel out, and Saturn will reverse and pass M44 for a third time in late May and early June. The crescent Moon will join them low in the west at twilight May 31 to create a pretty binocular scene. Mark this sky event on your calendar!

To find Cancer's second cluster, trace its southeastern leg away from the Crab's trapezoidal body to the 4th-magnitude star **Acubens** (from the Latin for "claw"). Center your view on Acubens, then shift your attention to the binocular field's western half. You should spot the dim glow of **M67**. You might even pick out a few faint stars shining within M67's haze.

Like M44, M67 is an open cluster, although its stars tell a different story. While stars in the Beehive are believed to be about 400 million years old, those in M67 date back 3 to 4 billion years. This makes M67 one of the oldest open clusters in the Milky Way and nearly as old as our solar system.

Let's close this month with a two-part Saturn challenge. Although a telescope works best for looking at the planet's spectacular rings, binoculars also can spot the rings' oblong bulge. I imagine Saturn as slightly elliptical through my 10x50s, but how about you? How low can you look and still tell that Saturn is oval? That's the first challenge.

The second challenge: Try to find Saturn's largest moon, Titan. Look for a dim, 8th-magnitude speck just beyond the planet. Give both a try, then drop me a line at phil@philharrington.net to let me know how you make out.

Once you've enjoyed these springtime treats, be sure to stop by Astronomy.com this month for some other tasty crab delicacies. Then, come back next month as we dive into the Big Dipper.

Until then, don't forget: Two eyes are better than one!

ONLINE EXTRA Cancer the Crab offers other great binocular targets in addition to those mentioned above. More objects await at www.astronomy.com/toc.

LOOKING FOR A GOOD DEAL?

Investigate our website and save!

optcorp.com
1.800.483.6287

- Explore our **used section…** it's always changing. Why buy from a stranger? Purchase fully warranted equipment from a name you trust!
- Examine our **specials section…** new and discontinued fully warranted products at exceptional prices!
- Check out our **demo and open-box section…** all with full manufacturer's warranties.
- California Tax Relief…If you are a California resident looking to make a big purchase and are afraid of the taxes…we can help!

Proudly representing:

Tele Vue • Meade • Celestron • SBIG • Takahashi • Coronado • JMI • Losmandy • Bisque • Vixen • William Optics • Canon • and many more!

Craig Weatherwax, "Star Sleuth" and Founder of OPT.

Open 7 Days
M-F 9a-8p, Sat 9a-6p and Sun 12p-5p (PST)

OPT

Oceanside Photo & Telescope • www.optcorp.com
918 Mission Avenue • Oceanside, CA 92054

Join our tradition of discovery

In the heart of Arizona's cool pine country

The planet Pluto and first evidence of the expanding universe were just two of the discoveries made at Lowell Observatory. Still an active research facility hosting excellent interactive exhibits, guided tours and telescope viewings, Lowell awaits your discovery.

. . .

There's more to discover here as well — The Grand Canyon and other nearby wonders. A renowned museum. Ancient ruins. Hiking. Biking. And our 1890s downtown filled with unique shops, great restaurants and live entertainment.

Ask for our FREE '06 Visitor Guide

Flagstaff

www.flagstaffarizona.org
888-774-6789

ASTRONOMY.COM

Giving you **more** of what **you** enjoy!

Visit **Astronomy.com** for these great offers:

- ☑ Premium **online-extra** stories and images
- ☑ Up-to-the-minute **sky event** coverage
- ☑ Space **weather**
- ☑ Massive **multimedia** gallery

See page 5 for your access code, or subscribe for unlimited access!

Astronomy.com

05X1428

---

www.william-optics.com/wo_shop/catalog

WO!

EZ Touch LAUNCH PRICE!

- Eazy Touch Alt-Az Mount US$ 498

Why do people choose an ALT-AZ mount? You know that already. We will tell you why you will choose *OURS*. It's easy and fast to use, easy to balance, it's light but steady like a rock and smooth: move it with a finger even at 300x! Made in Switzerland, it comes with a wooden tripod. Want the best choice to use your Fluorite Doublet to its fullest? Holds up to 6" with standard counterweights!

WILLIAM OPTICS USA

Toll Free: 1-866-918-6888 (For USA Only)
Tel : +1-714-898-7989 Fax: +1-714-892-6067
e-mail : wo@william-optics.com

10Y

ZenithSar 80 f/6.9 Fluorite Doublet
OTA
US$ 848

Binoviewers Package
US$ 198

© WO2006-G29

WOODLAND HILLS TELESCOPES

5348 Topanga Canyon Blvd
Woodland Hills, CA 91364
TEL: 818-347-2270 • FAX: 818-992-4486 • www.whtelescopes.com

FOR THE LOWEST PRICES & BEST SERVICES TO ORDER CALL TOLL FREE 1-888-4ASTRONOMY (1-888-427-8766) Phone Orders: Mon through Sat. 9-6 Pacific Standard Times

MEADE

NEW ETX®	LX90™ LNT	LX200® GPS	LX200R™ GPS	The NEW 10, 12,14, or 16 inch RCX telescope
90 PE, 105PE, 125PE	8",10",12"	7",8",10",12" or 16"	8",10",12",14" or 16"	

Introducing
Deep Sky Imager™
with AutoStar Suite™

New Deep-Sky Imager Pro II $599
with CCD RGB Color Imager Pro $699

Take Pictures Just Like These Your First Night Out

NGC891
Caldwell 23
AutoStar Suite
MEADE

TELE VUE OPTICS

TeleVue Optics sets demanding standards for all their products including TeleVue binoviewers In Stock and priced right at $1030. Al Nagler's prize winning eyepieces are here. The new Nagler type 6 with 84 degree FOV are in stock and available in these sizes 13mm, 11mm, 9mm,7mm, 3.5mm, 2.5mm $280 each The TeleVue 102i is the one and only stereo view telescope with unsurpassed clarity and at an unbelievable price. In stock and ready for delivery. Call for price quote. We have many more TeleVue products In Stock and ready for delivery.

FREE SHIPPING

CELESTRON TELESCOPES

NexStar 8i, 5i	NexStar 8,9¼,11 GPS	NEW CPC 8,9¼,11	CGE 8,9¼,11,14
Call for New Lower Prices	Call for New Lower Prices		

CORONADO

We now have the new Personal Solar Telescope P.S.T.-CaK in our store. It allows you to see and photograph solar flares and prominences safely. **$499.**
The MAXSCOPE 40 Telescope with BF10 – New Low Price – **$1699.**

LOSMANDY

New Gemini goto in stock

G11 Mount with dual axis drive

GM-8 mount, dual axis drive

CALL

CLOSEOUT CORNER

MEADE DS 2130 includes Autostar and tripod refurbished $199.00

MEADE ETX-90 COMPLETE WITH 884 TRIPOD AND ELECTRONIC EYEPIECE $299.00

WE SHIP ANYWHERE Visit our Web site www.whtelescopes.com or Call: 1-888 427-8766

ORION TELESCOPES & BINOCULARS

Our 31st YEAR

ACCESSORY SALE!

VISIT ORIONTELESCOPES.COM

(800) 447-1001

OrionTelescopes.com

EVERYTHING FOR THE AMATEUR ASTRONOMER — DELIVERED DIRECT

TELESCOPES

XT12
XT10
XT8
XT6

SkyQuest™ XT IntelliScope® Dobsonians

Space is infinite. Your patience is not. Avoid tedious truss-tube designs and get a Dob that's faster to set up, has a solid-wall tube for superior contrast, has altitude tension adjustment for optimal balance, uses a low-expansion Pyrex® primary mirror (10" and 12" models), is amply portable, and allows *computerized pointing* to 14,000+ objects. Get an Orion SkyQuest XT IntelliScope.

XT12 IntelliScope . . $1,089.95*	**XT8 IntelliScope . . . $599.95**
X10 IntelliScope . . . $769.95	**XT6 IntelliScope . . . $479.95**

* Prices *INCLUDE* optional Computerized Object Locator with 14,000-object database.

Orion® SkyView Pro 8 EQ Reflector
Terrific deep-space probe with f/4.9 parabolic optics and 2" focuser.
$769.95 with IntelliScope Computerized Upgrade Kit

Orion® SkyView Pro 150 EQ Mak-Cass
Great combination of power and portability at an affordable price.
$1,099.95 with IntelliScope Computerized Upgrade Kit

Orion® SkyView Pro 8 EQ Schmidt-Cass
See a myriad of celestial objects every night in stunning resolution.
$1,429.95 with IntelliScope Computerized Upgrade Kit

Orion Sirius™ EQ-G GoTo

New!

Sirius™ 80ED EQ-G GoTo Apo Refractor
This is one sweet package for CCD or DSLR imaging.
$1,499.95

New!

Sirius™ 8 EQ-G GoTo Schmidt-Cass
The 8" SCT gets a makeover with our newest heavy-duty GoTo mount.
$1,899.95

MOUNTS

Orion® Sirius EQ-G GoTo Mount
$999.95

New!

Meet the new price standard for heavy-duty GoTo mounts. The Sirius EQ-G features precision stepper motors and GoTo pointing with a 13,436-object database in the illuminated hand controller, PEC, backlash compensation, CCD autoguider port, and 13 slewing and tracking rates. Stainless steel, extendable tripod. Requires 12-volt DC power, sold separately.

ACCESSORIES

New!

Orion StarShoot™ Deep Space Color Imager
Capture amazing color shots of galaxies and nebulas with a single exposure! Thermoelectric cooling reduces noise for superior image quality. Includes MaxIm DL Essentials Edition software.
$399.95

Orion StarShoot™ Solar System Color Imager
See a live video image of the Moon or planets on your computer screen, then capture and stack individual frames. It's easy! Includes MaxIm DL Essentials Edition software.
$99.95

New!

SALE! Save 23%!

Stratus™ 68° Eyepieces
Get the "big picture" with these fully multi-coated, 68° eyepieces. Fit 1.25" and 2" focusers.
Now $95.95 ea.

SALE! Save 20%!

UltraBlock™ Narrowband Filters
Boost contrast of faint emission nebulas and combat light pollution.
Now from $63.95

SALE! Save 15%!

Shorty-Plus™ 2x 3-Element Barlow
Our finest short barlow provides a 2x power boost with any 1.25" eyepiece.
Now $59.45

SALE! Save 15%!

LaserMate™ Deluxe Collimator
Align your reflector's optics with laser precision for superior images.
Now $67.95

FREE Color Catalog!
Call toll-free (800) 447-1001 or request it online.
When ordering, mention key code WMA
Prices subject to change

We Treat Our Customers Like Stars!

24 Hour Toll-Free Orders: (800) 447-1001
OrionTelescopes.com

MONEY-BACK 100% Satisfaction GUARANTEE

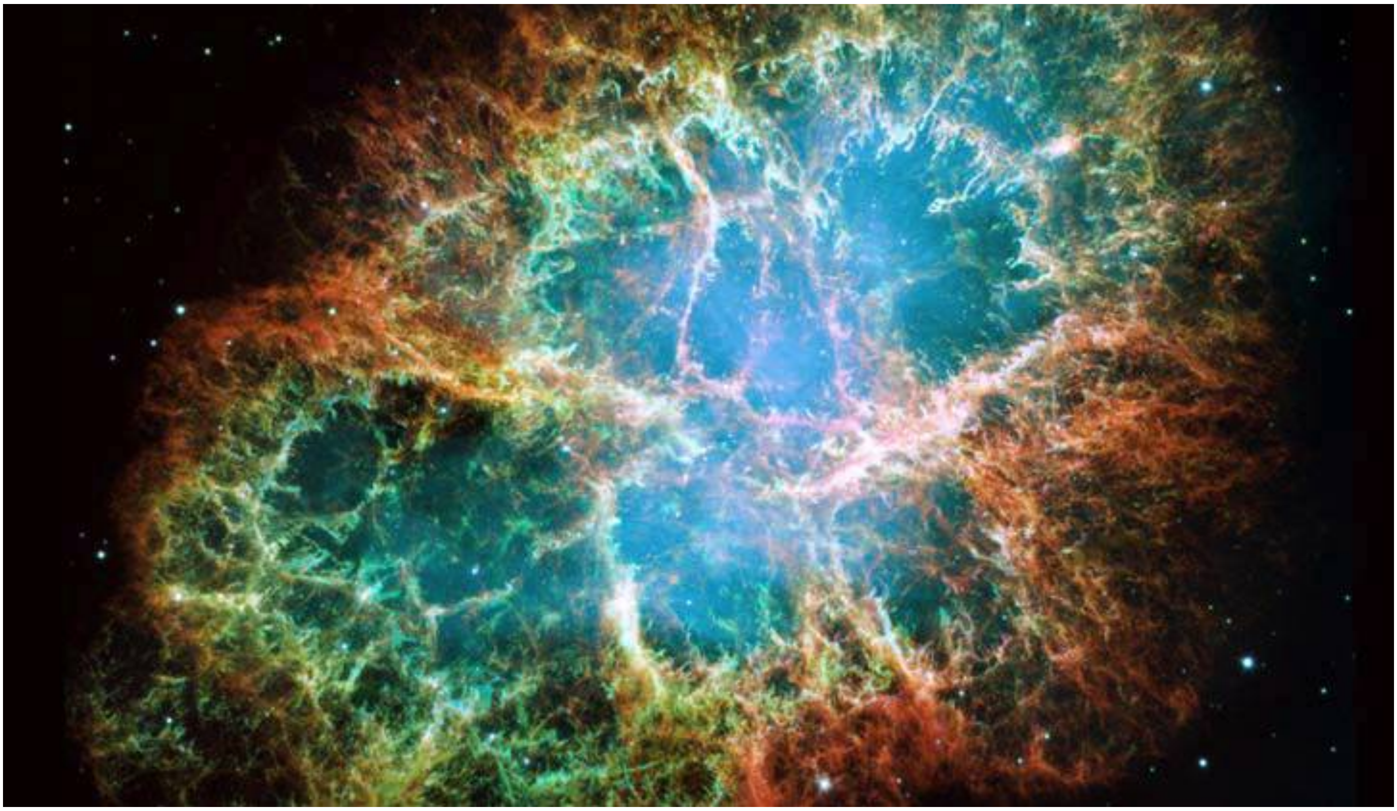
Information/Advice:
(800) 676-1343

IMAGINOVA

Seeing red Astronomers in Taiwan say fluorescing nanodiamonds — so small a hair's width encompasses 1,000 — likely create planetary nebulae's diffuse red-light emission.

For the latest news on space discoveries, spacecraft missions, and sky events, visit **Astronomy.com/news**

Astronews



NASA, ESA, J. HESTER AND A. LOLL (ARIZONA STATE UNIVERSITY)

BLOW UP. A new mosaic of Hubble Space Telescope images reveals the Crab Nebula, the remains of a star that exploded in 1054.

26 Spitzer search yields new clusters

28 Around the world in 80 minutes

30 Scientists predict GPS failures

32 Galaxies' urge to merge

Best-ever view of the Crab

Astronomers combined 24 individual exposures of the Crab Nebula taken with the Hubble Space Telescope's Wide Field Planetary Camera 2 (WFPC2) to create a stunning new portrait of the object.

The mosaic contains Hubble exposures from October 1999, January 2000, and December 2000. Blue reveals neutral oxygen, green shows singly ionized sulfur, and red discloses doubly ionized oxygen.

Allison Loll, a graduate student at Arizona State University (ASU), combined the separate WFPC2 exposures into the most-detailed view of M1 yet made. In addition to scaling and matching the images, Loll had to remove artifacts caused by cosmic rays streaming through the instrument. The final product took years to assemble; she admits she "remade these mosaics many, many times to get them right."

What makes the Crab look so different from other supernova remnants is what lies at its heart. Says ASU's Jeff Hester, a member of the WFPC2 science team, "Everything we see in the Crab is the product of the pulsar at its center." An intense magnetic field sweeps through the stellar debris 30 times each second. The Crab Nebula, formed by a supernova seen from Earth in 1054, lies 6,500 light-years away. — **MATTHEW QUANDT**

You'll Like What You See ...

About Vixen

Vixen astronomical products have been treating their owners to the delight of the night sky since 1949. Always respected by quality minded amateurs, Vixen today offers some of the latest technology encased in the solidity of the past. Take the "goto" SPHINX mount and STAR BOOK; a sturdy German equatorial mount for all types of scopes combined with the first electronic star chart hand-controller. The SPHINX is just one example of Vixen's ingenuity on display at Certified Stocking Vixen Dealers and in stock for you to take home and enjoy tonight.

GP-D2 Equatorial Mount

Deluxe Equatorial Mount

Geared for those seeking a portable, high-precision mount for astrophotography or simply visual observing, the GP-D2 is the perfect platform for more than just Vixen telescopes! Accurate tracking is achieved with dual 144-tooth brass worm wheels and gears. The R.A. worm is machined to 0.001 mm tolerance for accurate tracking, and all worm gears are individually inspected before assembly in Japan. Die-cast aluminum pares the weight of the GP-D2 down to 18.7 lbs. yet the design permits a carrying capacity of 22 lbs. Manual slow motion controls are provided.

R200SS 8" f/4 Richfield Newtonian

Advanced Imaging & Visual

At f/4 there's no room for error when forming the surface of a parabolic mirror. Vixen's solution is to execute each R200SS mirror with its High-Precision Poly-Order Aspherical Mirror Molding Technique. The result: exquisite state-of-the-art paraboloid form. Compact 28" length and only 11.7-lbs, the large 60mm drawtube allows for a whopping 2.6° x 1.7° field-of-view on 35mm format. The perfect imaging mate for the GP-D2 equatorial mount.

Recommended Accessories

Coma Corrector

Eliminates coma in full-frame imaging. Can be left on for visual use.

LV Eyepieces

(32x) (80x) (160x)

Our famous Lanthanum eyepieces are fully multi-coated with huge 20mm eye-relief for comfortable observation and easy eyepiece projection planetary imaging.

SPHINX Equatorial Mount

"Vixen's newest go-to mount is a winner." — Astronomy

SPHINX mount with its Internet upgradable STAR BOOK controller, is the culmination of a decade of design experience. SPHINX responds nimbly and precisely to your commands due to its lightweight design with low-rotational momentum. STAR BOOK is striking with its 4.7" LCD screen and powerful CPU that produces localized star charts with Constellations, "goto" menus for 22,725 celestial objects: Messier, NGC/IC, Solar System, stars, and more. Auto-guider port works with SBIG guiders. Mount is controllable through popular planetarium programs such as *TheSky6* (*Serious* or *Pro*) and *Starry Nights* (*Pro* or *Pro Plus*).

The Reviews are In: "A telescope mount for the 21st century"
***Astronomy* magazine, November 2005**

- "The Star Book is so easy to operate it flirts with user-interface perfection ... ."
- "As it stands now, the Sphinx is by far the easiest-to-use go-to mount."
- "Those interested in imaging should give this mount consideration."
- "The Sphinx is an extraordinary value because this amount of periodic error is normally encountered only in mounts 4 or 5 times its cost."
- "More good news: The mount is terrific."
- "To its credit, the screen worked well even at low temperatures — I subjected it to a test at -15° Fahrenheit (-26° Celsius) one night... ."

Recommended Accessories

Polar Axis Scope

6x20mm

for both hemispheres

Aluminum Case

Holds SPHINX, STAR BOOK, weights, battery case and more.

Tripod Carry Bag
Includes half-pillar pouch.

PORTA Alt-Az Mount

PORTA: Exceptionally Portable Mount!

Newly designed friction system for quickly pointing toward the object and hand tracking it with the 360° slow-motion controls. No fumbling with clutches or sectional slow-motion controls! Leave the counter-weights with the equatorials: simply balance scopes up to 9-lbs. on the altitude axis and start viewing! Standard Vixen dovetail mounting slot with lock and safety screw is fully SPHINX/GP-compatible. PORTA mount features interchangeable slow-motion knobs, tension adjustment and disassembly tools, built-in tool storage bay, tripod tray and aluminum legs.

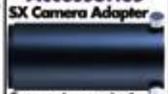
ED80Sf 80mm f/7.5 APO Refractor

Portable Affordable APO

Breakthrough price on an ED80Sf scope package including giant 9x50mm finder, dual T-thread flip-mirror with 1¼" eyepiece adapters, rotatable 2" eyepiece adapter with locking collar, Crayford focuser with tension/lock adjustment, tube rings with dovetail plate and telescope/accessory travel case! Included standard accessories make the ED80Sf the value leader in affordable 80mm APO scopes. Perfect size for PORTA mount makes this an exceptionally portable system.

Recommended Accessories

SX Camera Adapter



For eyepiece projection with flip-mirror and T-Ring.

LV Eyepieces

(15x) (67x) (150x)

Fully multi-coated with huge 20mm eye-relief for comfortable observation and eyepiece projection.

Certified Stocking Vixen Dealers

Adorama Camera / New York, NY
1-800-223-2500 adorama.com

Anacortes Telescope & Wild Bird / Anacortes, WA
1-800-850-2001 buytelescopes.com

Oceanside Photo & Telescope / Oceanside, CA
1-800-483-6287 optcorp.com

...at VixenAmerica.com

VIXEN AMERICA • 32 Elkay Dr. • Chester, NY 10918

☎ 845-469-8660 from 9 a.m. - 5 p.m. ET Mon - Fri

Pulsar buzz

Radio surveys show globular cluster Terzan 5 is a pulsar record-holder. It has at least 33 pulsars, including the fastest-spinning (716 times each second).

C. HELIKER/USGS

WHAT LIES BENEATH. Geophysicists take measurements across a Hawaiian lava tube's partially collapsed roof.

Radar reveals lava tubes

A team led by Hideaki Miyamoto of Japan's University of Tokyo has demonstrated a radar system with both the resolution and penetration to map lava tubes. Lava tubes are tunnel-like structures that form beneath the surface of a lava flow. Geologists usually recognize a lava tube only when part of the structure collapses, making it visible at the surface.

The new system easily detected a known lava tube on Mt. Fuji, and estimated its height and depth. Writing in the November 12, 2005, *Geophysical Research Letters*, the scientists suggest their new technique would be useful in future planetary exploration. Extinct lava tubes on the Moon and Mars could protect organisms from cosmic radiation, meteoroids, and temperature changes. The scientists suggest such sites may be of biological interest or offer safe havens for future human bases. — **FRANCIS REDDY**

A cloudy definition

JEFF MILLER

ANGRY SKY. Mammatus clouds descend from the underside of a thunderstorm's spreading anvil.

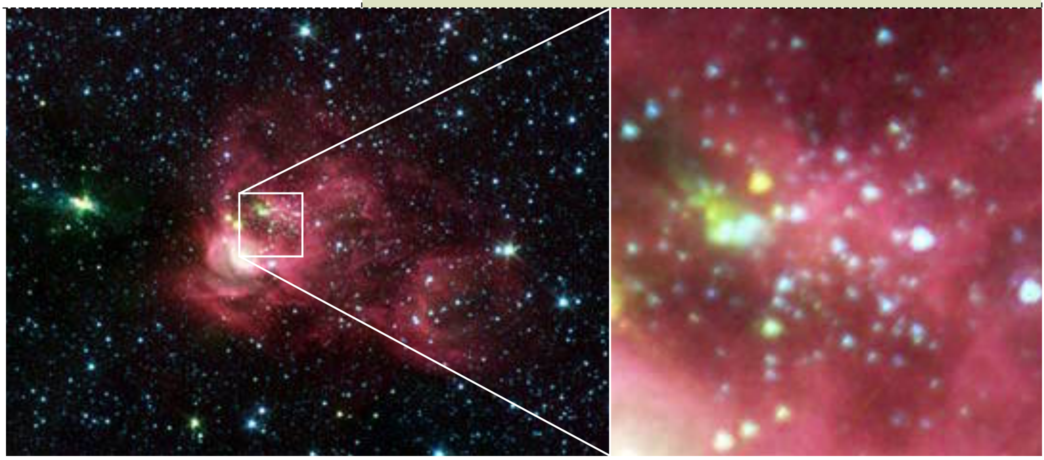
At the American Geophysical Union's fall meeting in December 2005, atmospheric scientists debated how to define a cloud. "The problem is that what we define a cloud as depends on the type of instrument we're using to define it," says Steven Ackerman, director of the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin, Madison.

Accurately defining and measuring clouds matters. Cloud cover affects weather forecasts, long-term climate predictions, and the amount of solar radiation reaching Earth.

But satellite readings of cloud cover over the same region may vary by as much as 10 percent depending on the instruments used. High, thin cirrus clouds are difficult to define precisely. At what point does a cirrus cloud become so diffuse it's no longer considered a cloud? Moreover, a given area may contain more than one type of cloud.

With no consensus among atmospheric scientists, Ackerman says, the debate over accurate cloud measurement continues. — **LAURA LAYTON**

Spitzer search yields new clusters



NASA/JPL/SSC

SWADDLED STARS. The GLIMPSE team's computer search identified this new cluster in Aquila. Warmer colors represent longer infrared wavelengths in this false-color Spitzer view.

Astronomers on the Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) team have uncovered 92 new Milky Way star clusters. An automated method that sifts through data collected by NASA's Spitzer Space Telescope found two-thirds of the objects.

"These little guys were quite hard to find," says Emily Mercer, a doctoral student at Boston University who developed the technique with her advisor, Dan Clemens. The automated search detected 59 new clusters, while visual inspection of GLIMPSE images identified 33 additional objects. Nearly all of the clusters are less than 3' across. More than twice as many clusters were detected below the galactic plane as above.

"By making the galactic plane transparent, Spitzer opens a new door for astronomers to study the Milky Way," says Ed Churchwell at the University of Wisconsin, Madison, who leads the GLIMPSE team. "Some of the most interesting science likely to come out of this project will be serendipitous discoveries, which will open up entirely new avenues of inquiry."

Clemens says Mercer's scan for clusters is "the most successful automated effort to date." The researchers published their findings in the December 2005 *Astrophysical Journal*. — **F. R.**

SCOPETRONIX
QUALITY ASTRONOMY PRODUCTS

TOLL FREE (866) 458-7658
LOCAL (239) 945-6763
FAX (239) 458-9325

Largest Telescope Dealer in the Southeast
10,000 sq ft of Telescopes & Accessories - Over 500 Telescopes in Stock!

Tele Vue   Meade   CELESTRON

MEADE™

ETX-90PE
ETX-105PE
ETX-125PE

MEADE LX200GPS-SMT 14", 12", 10", 8", 7"
LX90-LNT

We stock all popular telescopes and accessories from Meade, Celestron and TeleVue. We ship telescopes nationwide and ship most accessories worldwide. Sales tax is not charged by us outside of Florida. See our website for a huge selection and 24 hour online ordering.

CELESTRON™   Tele Vue™

NEW!

EZ-Pix II   Universal Digital Camera Adapter

Taking digital pictures through your scope is as easy as 1..2..3!

EZ-Pix II truly lives up to its name. Simply twist the large knob to secure it onto your eyepiece. Attach your camera by its tripod thread and turn the easy to use micrometric type adjustments until your camera lens is centered over the eyepiece. Once centered tighten the lock knob to secure your adjustments solidly in place. Easily switches from eyepiece to eyepiece or to different cameras. Available in 2 sizes to fit standard 1.25” telescope eyepieces and larger eyepieces commonly found on spotting scopes. Unlike similar units on the market ours is truly universal, including an extension plate to allow you to use cameras with long extending lenses such as the Nikon 5400/5700/8400/8700/8800, Olympus 2000-8000 series, Sony DSC series, Canon A and G series, Minolta DiMage and many, many more.

STEZPIX2S	Small, fits eyepieces 28mm to 45mm.......	**59.00**
STEZPIX2L	Large, fits eyepieces 43mm to 65mm.......	**79.00**

ScopeTronix Digital Camera Solutions
We have the worlds largest selection of digital camera adapters

Moving up to a Digital SLR camera?
The MaxView-DSLR is for you!

NEW!

DSLR II shown
on a Canon 10D*

Finally a variable projection adapter large enough to hold ANY eyepiece! Now you can use your best eyepieces for astrophotography. The picture at right shows the 1.25" version (left), the 2" version (right) and a standard sized projection adapter between them for scale. The 1.25" version will accept any 1.25" eyepiece. The 2" version will accept any 1.25" or 2" eyepiece...yes even a 31mm Nagler! Both versions include a removable MaxPower lens to increase magnification and allow use in scopes with very little back focus. These are variable length adapters allowing you to adjust the magnification in small increments to fill the frame. Change eyepieces in seconds. Machined from solid aluminum, anodized black with a knurled grip ring. 2" version includes 1.25" adapter. Both units are T threaded for use with standard T-Rings. Can be used with 35mm SLR cameras too! *Camera not included.

1.25” MaxView-DSLR 2.00”

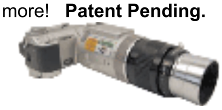
1.25” *MaxView-DSLR* (STSLR1) $129.00 | 2” *MaxView-DSLR* (STSLR2) $189.00

MaxView™ & MaxPower™ Lenses

S&T Hot Product 2003!

Our award winning MaxView 40 and new MaxView II Digital Camera Adapters are specially designed eyepieces for use with digital cameras. Designed to give the least vignetting, even when used with large lensed cameras. The MaxView 40 is 1.25” format while the MaxView II is 2” format. We carry dozens of adapter kits to fit either MaxView to most all digital cameras with threaded lenses. Our new MaxPower™ lenses thread into the bottom of the MaxView eyepieces to increase magnification by 60% while maintaining the desirable properties of the MaxView eyepieces. We also have versions made specifically for use with Microscopes and most popular nature scopes such as Swarovski, Pentax, Leica, Zeiss and more!   **Patent Pending.**

1.25” MaxView $129.95



*Mounted on Sony 717

2” MaxView II $189.95

Awarded
“Hot Product”
SKY
& Telescope
Magazine™
2003

MaxPower 1™ 1.25” 39.00
MaxPower 2™ 2.0” 69.00

The Digi-T™ System
The world’s best selling Digicam Adapter!

Pricing from
$59.95 to $119.95

The Digi-T system allows you to use most popular plossl eyepieces with your digital camera. We have dozens of kits to fit all popular digital cameras. *See complete details on our website.*

Fits: Meade 4000 Plossls, Celestron NexStar Plossls, ScopeTronix ST Series, Orion Sirius Plossls, and many more eyepieces with removable rubber eyeguards. *Patent Pending

GPS for your Autostar!

Easy to install unit adds GPS functionality to many scopes. Versions to work with Meade ETX, LX90, LX200 (GPS and Classic), No more entering the time, date, and location! It is all entered for you at very high accuracy! See our website for full details and model number for your particular telescope.

STARGPS $199.00

ScopeTronix 4 in 1 Multi-Mate Alignment Tool

The Multi-Mate has four handy tools for your GOTO scope. It’s a compass, a level, a dust cap, and a desiccant chamber. To find “home position” simply place it in the eyepiece port and swing the OTA till the compass indicates North, flip it over and use the bubble level to level the OTA. When storing your scope use it as a dust cap and the built-in desiccant packet will also help prevent mold damage to your optics. Desiccant is easily replaceable by unscrewing the end. Machined aluminum, anodized black.

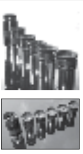
STMM	ScopeTronix 4 in 1 Multi-Mate.........................	**24.95**
STMMD	Replacement desiccant (10 Packets)...............	**5.95**

ScopeTronix Thread On Solar Filters for ETX & Tele Vue scopes

Custom machined black aluminum filter cell securely threads onto telescope.

STSF60	fits ETX60 and ETX70..........	**64.95**
STSF90	fits ETX 90...........................	**84.95**
STSF105	fits ETX 105.........................	**94.95**
STSF125	fits ETX 125.........................	**99.95**
STSF76	fits Tele Vue 76.....***NEW!***........	**79.95**
STSF85	fits Tele Vue 85.....***NEW!***........	**89.95**
STSFB	fits Canon 50mm IS(2)...........	**99.95**

ScopeTronix ST Series Plössl Eyepieces



STPL04	4mm ST Series Plössl	**37.95**
STPL06	6mm ST Series Plössl	**37.95**
STPL09	9mm ST Series Plössl	**37.95**
STPL12	12mm ST Series Plössl	**37.95**
STPL15	15mm ST Series Plössl	**37.95**
STPL20	20mm ST Series Plössl	**37.95**
STPL25	25mm ST Series Plössl	**37.95**
STPL32	32mm ST Series Plössl	**42.95**
STPL40	40mm ST Series Plössl	**42.95**
STPLSET	Complete Set (9)......	**249.00**

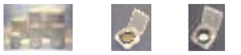
ScopeTronix Barlow Lenses

STBAR2	2x	**39.95**
STBAR3	3x	**42.95**
ST2BAR2	2x 2”	**79.95**

Color Filter Set
For 1.25” Eyepieces

STCFS...37.95

ScopeTronix Eyepiece Bottles & Filter Cases



ScopeTronix "Bolt-Style" Eyepiece Bottles

STEPB1	Eyepiece Bottle - 1.4" ID, 1.9-2.6" Length	**3.00**
STEPB2	Eyepiece Bottle - 1.6" ID, 3.2-4.7" Length	**3.00**
STEPB3	Eyepiece Bottle - 2.0" ID, 3.2-4.7" Length	**4.00**
STEPB4	Eyepiece Bottle - 2.0" ID, 3.2-4.7" Length	**5.00**
STEPB5	Eyepiece Bottle - 2.5" ID, 4.7-7.8" Length	**6.00**
STEPB6	Eyepiece Bottle - 3.1" ID, 4.7-7.0" Length	**7.00**

ScopeTronix Filter Cases

STBOXS	Small (1-1/4“ filter size box)............	**1.95**
STBOXL	Large (reducer/corrector size box)..	**2.95**

Parfocal Rings

1.25”	**STPRING**	**7.95**
2.0”	**STPRING2**	**8.95**

ScopeTronix ETX & NexStar Piggy Back Camera Mounts

STPB70	ETX-60/70......	**42.95**
STPB90	ETX-90...........	**49.95**
STPB105	ETX-105.........	**54.95**
STPB125	ETX-125.........	**64.95**

Autostar Case

Protect your Autostar from the dew and keep it working like new!

SASC 34.95

ScopeTronix Accessory Tray for ETX

Accessory Tray for ETX

STTRAY90	ETX90....	**39.95**
STTRAY105	ETX105..	**44.95**
STTRAY125	ETX125..	**49.95**

Replacement Eyeguard

Fits many common 1.25” eyepieces.

STEYEG 2.50

ScopeTronix Flexi-Focus™ for ETX Telescopes

Oversized knob and flexible shaft allow crisp, sharp focusing even when OTA is pointed straight up!

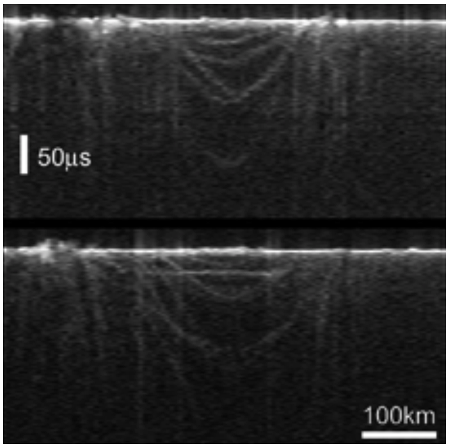
STFLEX70	For ETX-60/70.....	**34.95**
STFLEX90	For ETX-90..........	**34.95**
STFLEX125	For ETX-125......	**34.95**

Flexible shaft reduces vibrations Achieve sharp focus fast!

ScopeTronix designs and manufactures many unique products like the patent pending Maxview’s, Digi-T, Flexi-Focus, etc... Dealer inquiries are always welcome!

WWW.SCOPETRONIX.COM
24 HOUR ONLINE SHOPPING & SECURE ORDERING

ScopeTronix Astronomy Products ● (239) 945-6763
914 SE 14th Place ● Cape Coral, Florida 33990



ESA

PINGED CRATER. Radar shows buried martian craters as parabolic arcs.

Under the surface

Mars Express, the European Space Agency (ESA) spacecraft orbiting the Red Planet, used its Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) instrument to provide the first 3-D views beneath the surface.

The data revealed a shallow, 155-mile-diameter (250 kilometers) depression in Chryse Planitia that's invisible from the surface. MARSIS' ground-penetrating radar shows distinctive arcs that correspond to ring structures, and a flat feature nearly 100 miles (160 km) long.

The MARSIS team interprets the rings as the rims of one or more impact basins, and the flat surface, at roughly 1 to 1.5 miles (1.5 to 2.5 km) deep, as the boundary between the crater's floor and overlying material — possibly an earlier water-ice mix that flowed from nearby Valles Marineris.

"[The detection of buried impact basins] may force us to reconsider our chronology of the formation and evolution of the surface," comments NASA's Jeffrey Plaut, a MARSIS team member.

MARSIS also found a water-ice layer roughly a half-mile (1 km) thick at the north polar cap but has found no evidence of subsurface liquid water anywhere on the planet. ESA has extended the Mars Express mission for another 2 Earth years, beginning last December, in part to allow MARSIS to continue searching for water.

— **LAURA BAIRD**

HOTEL ON HIGH. Robert Bigelow's prototype Genesis module will inflate once it reaches orbit. This technology harks back to the earliest days of the Space Age. Bigelow, a Las Vegas businessman, envisions future modules with volumes equivalent to that of the International Space Station's. BIGELOW AEROSPACE

Around the world in 80 minutes

At the beginning of the Space Age, the most delightful satellites to watch in the dawn and dusk skies were inflatable orbiting balloons like Echo I and II. They were so bright, they showed up clearly even against city lights. And they orbited at such high altitudes, visible passes occurred all night long during the summer. Smaller rocket bodies would flash to the drumbeat of their end-over-end tumbles, but the big, bright balloons were the skywatchers' favorites.

These satellites were big because gas inflated them from tightly packed balloons to giant, gleaming 100-foot-diameter (31 meters) spheres. But they also went extinct because they ran out of useful applications.

Now, a new generation of inflatable space vehicles is on the horizon. They won't be as big as the original balloons, nor even as big as existing hard-metal structures like space stations. But they may provide more good sky-viewing, and, if the project works out, some skywatchers may actually wind up aboard the inflatable vehicles.

This private project involves testing habitable structures for a future space hotel. Funded by real-estate magnate Robert Bigelow of Las Vegas, the project has overcome the "giggle factor" of looking totally absurd and is now moving into actual flight tests. It will be at least 5 years — maybe even 10 — before private launch vehicles could service a commercial facility in orbit, but that gives entrepreneurs more time to test and deploy prototypes.

The basic module, called Nautilus, will contain a volume slightly smaller than that of the International Space Station. A one-third-scale model unit called Genesis is slated to launch later this year aboard a commercially purchased Russian rocket. Genesis will test the nitrogen-gas-inflation technology and measure the unit's long-term air tightness during a period of several years. Follow-on, scaled-down payloads will add oxygen and carry life-support equipment for similar testing.

Genesis weighs about 2,400 pounds (1,100 kilograms) and fits into a launch canister about 9.8 by 3.3 feet (3 by 1m) across. The Genesis module itself is a 26-foot-long (8m) cylinder that includes windows and a simulated airlock to test the craft's pressure seals.

The launch vehicle, a Dnepr booster, will blast off from Kazakhstan's Baikonur Cosmodrome early in 2006. Experts expect Genesis will be placed into an orbit about 373 miles (600 km) high with an inclination of about 65° to Earth's equator — a path rife with observation opportunities for skywatchers.

— **JAMES OBERG**

Understanding the Universe: An Introduction to Astronomy *and* What's New in Astronomy, 2003

Master the cosmos in 42 hours with these two exciting recorded lecture series

Now you have the opportunity to gain a comprehensive understanding of the cosmos in two exciting courses, **Understanding the Universe: An Introduction to Astronomy** and **What's New in Astronomy, 2003.** Your host is the dynamic astronomer, lecturer, and author, Professor Alex Filippenko.

These courses begin and end in wonder and awe. Whether you are a seasoned student of astronomy or a newcomer to its marvels, these courses can give you fresh insight into the astounding comprehensibility of the universe, and the mind-boggling mysteries that still remain.

Why Now?

These courses, taught at this time, by this professor, are scientific adventure at its best.

We are living in a "golden age" of astronomical research and discovery. Ten years ago, black holes and planets around other stars had not been observed. Now, they are discovered every month. Ten years ago, the universe was thought to be a different size and age than we now think it is. Ten years ago, scientists could not find the 90% of the universe that was "missing" if the Big Bang theory was true—and they still haven't found it.

In these 56 expansive, 45-minute lectures, you'll range over the history of astronomy from the ingenious calculations of the ancient Greeks to the latest theoretical speculations and technological breakthroughs, including the vast change in our understanding made possible by a handful of special telescopes.

You'll explore, in depth, everything from our own solar system to the farthest detectable galaxies, and learn about scientific evidence on topics such as the Big Bang theory and the prospects of extraterrestrial intelligence and interstellar travel.

A "Superstar" Professor

Professor Alex Filippenko of the University of California at Berkeley has done award-winning research on topics such as supernovae, black holes, active galaxies, and observational cosmology. In 1998, *Science* magazine credited Professor Filippenko and his international team of astronomers with the "Science Breakthrough of 1998." He has won both of his university's top teaching awards, and has been voted "Best Professor on Campus" by students four times. Professor Alex Filippenko will make the universe comprehensible for you.

© Digital Vision, Ltd.

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This approach also enables us to fill your order immediately: 99% of all orders placed by 2:00 p.m. eastern time ship that same day. Order before April 29, 2006 to receive these savings.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group, we choose only those rated highest by panels of our customers. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses. We've been doing this since 1990, producing more than 2,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another or we will refund your money promptly.

Lecture Titles

Understanding the Universe:
An Introduction to Astronomy

A Grand Tour of the Cosmos ... Journey Through Space and Time ... Light—The Supreme Informant ... The Fingerprints of Atoms ... Tools of the Trade ... Space Telescopes and the Celestial Sphere ... Our Sun—The Nearest Star ... Lunar Phases and Glorious Eclipses ... The Early History of Astronomy ... The Copernican Revolution ... On the Shoulders of Giants ... One Small Step—The Earth and Moon ... Paradise Lost—Venus and Mars ... Planetary Behemoths—Jupiter and Saturn ... Distant Worlds and Solar System Debris ... Comets and Catastrophic Collisions ... Distant Suns ... Social Stars—Binaries and Clusters ... Nature's Nuclear Reactors ... The Fate of Our Sun ... Exploding Stars—Celestial Fireworks ... The Corpses of Massive Stars ... Hearts of Darkness ... The Quest for Black Holes ... Starting at Home—The Milky Way ... One Giant Leap—Other Galaxies ... The Dark Side of Matter ... The Birth and Life of Galaxies ... Quasars—Cosmic Powerhouses ... In the Belly of the Beast ... Are We Alone? The Search Begins ... Communicating with Extraterrestrials ... The Expansion of the Universe ... The Age of the Universe ... The Geometry and Fate of the Universe ... Einstein's Biggest Blunder? ... Echoes of the Big Bang ... In the Beginning ... The Ultimate Free Lunch? ... A Universe of Universes

What's New in Astronomy, 2003

From Dawn to Dusk ... Exploring the Night Sky ... Recent Discoveries in Our Solar System ... Other Worlds Galore! ... The Formation and Evolution of Stars ... Supernovae—Catastrophic Stellar Explosions ... Gamma Ray Bursts and the Birth of Black Holes ... Observational Evidence for Black Holes ... Einstein's Relativity ... Cosmology and Cosmic Expansion ... The Birth and Evolution of Galaxies ... The Accelerating Expansion of the Universe ... The Stuff of the Cosmos ... Dark Energy—May the Force Be With You ... Theories of Everything, and Hidden Dimensions ... Our Universe, One of Many?

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.™

SAVE UP TO $680!
OFFER GOOD UNTIL APRIL 29, 2006

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/3astr

THE Great Courses®
THE TEACHING COMPANY®
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 20149

Please send me **Understanding the Universe: An Introduction to Astronomy** *and* **What's New in Astronomy, 2003**, which consists of fifty-six 45-minute lectures, with complete lecture outlines.

☐ **DVD $199.90** (std. price $879.90) **SAVE $680!**
plus $25 shipping, processing, and lifetime satisfaction guarantee.

☐ **Videotape $159.90** (std. price $699.90) **SAVE $540!**
plus $25 shipping, processing, and lifetime satisfaction guarantee.

☐ **Check or Money Order enclosed**

* Non-U.S. Orders: Additional shipping charges apply.
Call or visit the FAQ page at our website for details.
**Virginia residents please add 5% sales tax.

Charge my credit card:

☐ VISA ☐ MasterCard ☐ DISCOVER NOVUS ☐

ACCOUNT NUMBER EXP. DATE

SIGNATURE

NAME (PLEASE PRINT)

MAILING ADDRESS

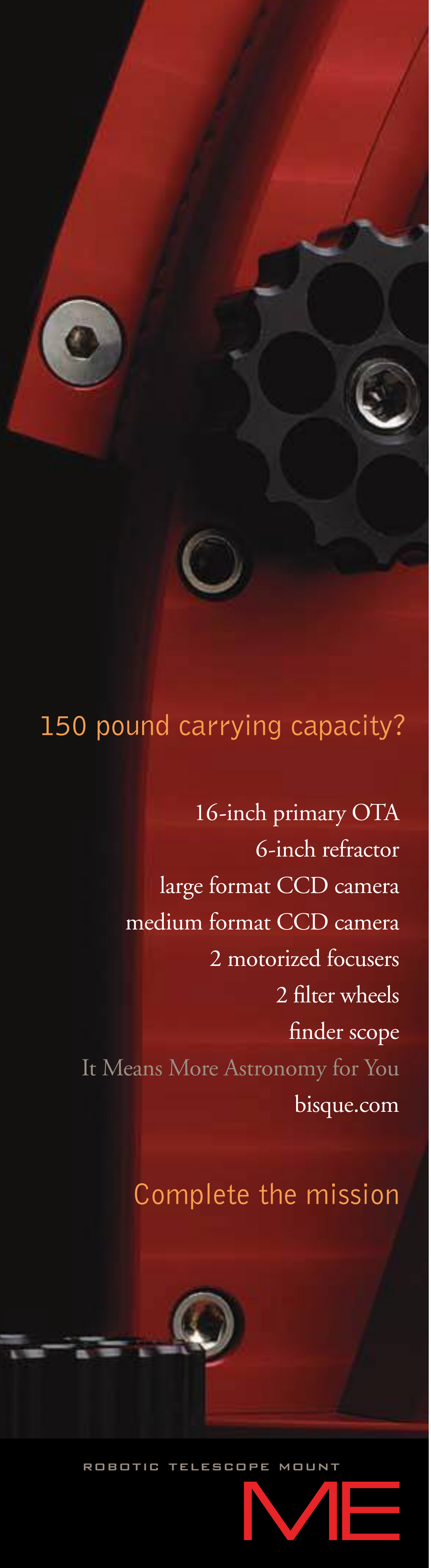
CITY/STATE/ZIP

PHONE *(If we have questions regarding your order—required for international orders)*

☐ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

Special offer is available online at www.TEACH12.com/3astr

Offer Good Through: April 29, 2006


150 pound carrying capacity?

16-inch primary OTA
6-inch refractor
large format CCD camera
medium format CCD camera
2 motorized focusers
2 filter wheels
finder scope
It Means More Astronomy for You
bisque.com

Complete the mission

ROBOTIC TELESCOPE MOUNT
ME

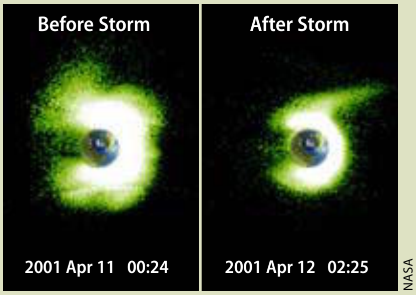
Scientists predict GPS failures

Scientists report solar storms may throw off Global Positioning Satellite (GPS) readings by tens of yards. They hope future space-weather reports will warn GPS users of potential problems when the Sun takes aim on Earth.

Solar storms peel away clouds of charged particles surrounding Earth, say NASA scientists. A single 2001 event stripped away 36 metric tons of matter every hour. During such events, the moving cloud can create a zone of radio disturbance several hundred miles wide. Along its edges, this type of disturbance can throw off GPS readings.

A new study, presented at the American Geophysical Union's December meeting in San Francisco, says it may be possible to inform GPS users — from farmers to pilots — when their receivers will display the wrong information.

Anthea Coster of MIT's Haystack Observatory in Westford, Massachusetts, Jerry Goldstein of the Southwest Research Institute in San Antonio, and Toni Mannucci of NASA's JPL in Pasadena, California, used GPS receivers to probe the ionosphere, an atmospheric layer electrified by the Sun.



NASA

SPACE EROSION. On April 11, 2001, a solar storm stripped mass from a cloud of charged particles surrounding Earth. The layer (green) was about a third larger before (left) than after (right) the storm passed.

While monitoring the ionosphere during solar storms in 2001 and 2003, Coster and her colleagues discovered that its changes were far from chaotic. Changes in Earth's magnetic field trigger powerful electric fields in the atmosphere's outermost layers. These fields move over the ionosphere like a cold front slides across a continent.

When such a disturbance occurs over North America, poor radio reception occurs along a corridor a few hundred miles wide. Coster says GPS receivers won't soon be able to compensate, but space-weather reports telling pilots not to rely on GPS for a couple of hours would help. — **BAS DEN HOND**

Is "Buffy" an interstellar fugitive?

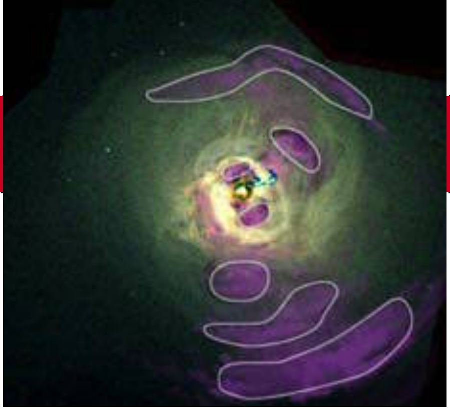
A newly discovered Kuiper Belt object may once have orbited a star other than the Sun.

In December, a team of astronomers working in Canada, France, and the United States announced the discovery of a Kuiper Belt object they dubbed Buffy (officially, 2004 XR_{190}). Buffy is about half Pluto's size, lies about 5.4 billion miles (8.8 billion kilometers) from the Sun, and orbits in a path angled 47° with respect to the planets' plane.

Astronomer Scott Kenyon of the Smithsonian Astrophysical Observatory thinks Buffy may have wandered sunward from another star. Together with the University of Utah's Ben Bromley, Kenyon theorized in a 2004 *Nature* article that objects in highly inclined Kuiper Belt orbits might have been captured when another star passed near the Sun early in its history.

"It's not clear, but there is the possibility," Kenyon says. These objects tell us more about the solar system's history than do other objects because they haven't experienced many gravitational nudges from other objects since their capture.

If Buffy is a captured planetoid from another star, then the search for extrasolar planets just got a lot closer to home. — **L. L.**



NASA/CXC/IoA/A. FABIAN ET AL.

ENERGY GEYSER. Purple marks the Perseus galaxy cluster's low-pressure zones.

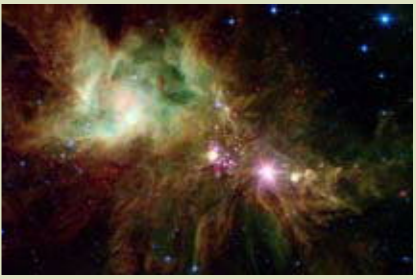
Far-reaching black hole

Recent observations show a black hole's influence extends farther than previously thought. Scientists observed the Perseus galaxy cluster for 280 hours using NASA's Chandra X-ray Observatory. They resolved low-pressure regions in the hot gas surrounding NGC 1275, the central galaxy. At its center lies a supermassive black hole.

High-speed plumes of energetic particles from the black hole move intergalactic gas and create these low-pressure areas.

"The plumes show that the black hole has been venting for at least 100 million years," says Jeremy Sanders of Cambridge University. Venting heats the gas and prevents it from cooling and coalescing into stars.

The scientists' research will appear in an upcoming issue of the *Monthly Notices of the Royal Astronomical Society*. — **LIZ KRUESI**



NASA/JPL-CALTECH/P. S. TEIXEIRA (CfA)

STELLAR YOUTH.

Spitzer sees young stars

The Spitzer Space Telescope's infrared eyes have found a stellar nursery under a dusty cover in NGC 2264, the Christmas Tree Cluster and its accompanying nebula. Infant stars only 100,000 years old are pink in this composite image; the most massive infants show as red. Green highlights organic molecules mixed with gas. — **L. K.**

Built for Astronomers by Astronomers

For over 20 years, astronomers worldwide have relied on one constant –TheSky6 Astronomy Software. While others have come and gone, innovations in TheSky6 continue to enrich your astronomy experience.

Ground breaking innovations, such as encoder-based telescope control, integrated CCD camera and telescope control, ingenious algorithms that aid in identification of celestial objects in CCD images, integrated access to the Digitized Sky Survey, and automation technology that operates robust observatories – are but a few.

Innovations that you count on, all from one source. TheSky6 Astronomy Software – the one constant that does it for you.

bisque.com

TheSkySix
ASTRONOMY SOFTWARE
Astronomy's engine

BRIEFCASE

Right on time

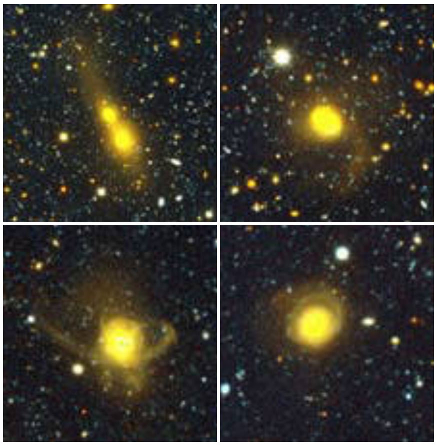
After 31 years of observing the 400-year-old white dwarf G117-B15A, astronomers at McDonald Observatory in Austin, Texas, have measured a change in its pulsation period. The white dwarf slows 1 second every 8.9 million years. The stellar remnant "ticks" every 215 seconds and is the most precise timekeeper yet found. The team reported its results in the December 1, 2005, *Astrophysical Journal*. — **L. K.**

High-plains crater dated

Vance Holliday of the University of Arizona, Tucson, and his colleagues have pinned down the age of the Odessa impact craters in the Texas high plains. The main crater is about 520 feet (160 meters) wide and nearly 100 feet (30m) deep; four smaller craters lie nearby. The team reports in the December issue of *Geology* that the crater formed about 63,500 years ago. — **F. R.**

Tidal sound

Undersea seismic sounds called T waves reveal a tidal pulse. A team led by Hiroko Sugioka at Japan's Agency for Marine-Earth Science and Technology in Yokosuka found that T-wave travel times change slightly twice a day. Lunar and solar tides, the team says, force undulations in the ocean layer channeling the sounds. The study will appear in an upcoming issue of *Geophysical Research Letters*. — **F. R.**



COURTESY PIETER VAN DOKKUM (YALE UNIVERSITY)

FREEZE FRAME. *Top*: **Tides begin their work shredding galaxies into broad starry fans even before they collide.** *Bottom*: **Trails of debris surround galaxies that have merged.**

Galaxies' urge to merge

Yale astronomer Pieter van Dokkum studied the tidal features of 126 nearby red elliptical galaxies and found intriguing results. During the past 2 billion years, more than half of the massive nearby galaxies have collided and merged with another galaxy.

"We needed data that are very deep over a very wide area to provide statistically meaningful evidence," says Van Dokkum. Two galaxy surveys met his criteria: the Multiwavelength Survey by Yale-Chile (MUSYC) and the National Optical Astronomy Observatory (NOAO) Deep Wide-Field Survey. Both surveys imaged an area 5,000 times larger than the Hubble Space Telescope's Deep Field.

Of the 126 galaxies Van Dokkum studied, 53 percent had asymmetries, including tails and wide fans of stars. "Our study found these common massive galaxies do form by mergers," he says. "The mergers happen quickly, and the features that reveal the mergers are very faint and, therefore, difficult to detect."

Van Dokkum's findings, which support existing predictions regarding the formation of large-scale cosmic structure, appeared in *The Astronomical Journal*'s December 2005 issue. — **L. L.**

New Horizons aims at Jupiter

NASA's New Horizons one-way mission to Pluto, the Kuiper Belt, and beyond is en route to its first target, Jupiter. The probe's January 19 launch ensured it would be able to swing past the solar system's most massive planet in late February 2007 for an extra speed boost.

"It's now our job to be good stewards of the spacecraft, and to learn to fly it in the environment it was built for," says principal investigator S. Alan Stern.

Missing this opportunity would have added 3 years to the mission's already lengthy cruise to Pluto. New Horizons is scheduled to fly past Pluto July 14, 2015. — **L. L.**

NASA

BY JOVE. NASA's Pluto probe will first target Jupiter.

Comet sampling a blazing success

COMET DUST RETRIEVED. NASA

The Stardust mission's goal to catch comet dust and interstellar grains succeeded beyond scientists' wildest dreams.

"We were absolutely thrilled to see thousands of impacts on the aerogel [collector]," says Don Brownlee, an astronomer at the University of Washington and Stardust's principal investigator. Aerogel, the collector's featherweight core, slowed down the speedy particles without altering them.

The collector grabbed tiny bits of dust captured January 2, 2004, when Stardust passed within 149 miles (240 km) of Comet Wild 2 (pronounced "Vilt" 2). Before the comet encounter, Stardust also snared interstellar grains drifting through the solar system.

Shortly before 3 A.M. Mountain time January 15, the 101-pound (46 kilogram) capsule plunged into the atmosphere at nearly 29,000 mph (47,000 km/h) — the fastest re-entry speed of any return capsule — and streaked across California and Nevada skies. — **F. R.**

Shop Online With Confidence On The Ultra Secure

SCOPECITY.COM

Experience the Largest and Most Complete Optical Centers in the World

EXPERT HELP 1.800.235.3344

Scope City Features All Major Brands at Discount Prices.

MEADE
PARKS
LUMICON
TeleVue Visionary
CELESTRON
Vixen
Canon
LOSMANDY
Thousand Oaks Optical
SBIG
Starry Night
KONUS
WILLIAM OPTICS
STELLARVUE
KENDRICK ASTRO INSTRUMENTS
Nikon
CORONADO
PENTAX
FUJINON
JMI JIMS MOBILE INC
TELRAD

For the Latest in Astronomical Equipment and Accessories, Shop Online, Visit Any SCOPE CITY Center or Call Us Directly.

SCOPE CITY CENTERS:

SIMI VALLEY, CA 805/522-6646
SHERMAN OAKS, CA 818/789-5805
COSTA MESA, CA 714/957-6900
SAN DIEGO, CA 858/277-6686
SAN FRANCISCO, CA 415/421-8800
LAS VEGAS, NV 702/947-2673

Scope City

Scope City, Inc. 730 Easy Street, Simi Valley, CA 93065, USA

riverscamera.com

MEADE Accessory Headquarters

Hot Picks from MEADE:

DEEP SKY IMAGER $299.95 Phone or Web
Free Shipping

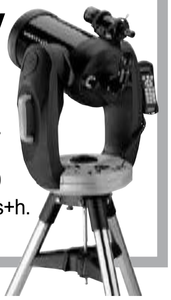
ETX CELESTIAL Observers Starter Kit $99.95 Phone or Web
Free Shipping

SERIES 5000 Ultra Wide Angle Eyepiece
In Stock
Free Shipping

Barry Nation, over 35 years with Rivers

CELESTRON®

New SkyAlign Alignment Technology
Fast, easy alignment. Simply choose three bright stars. Telescope does the rest. CPC800 $1899.00 + $95 s+h.



TeleVue®
Factory Authorized
DEALER

Large Selection of Televue Eyepieces & Accessories. See the Vixen Sphinx Mount in Store.

We know MEADE RCX Telescopes.
Factory trained staff members. Call Us!

Rivers CAMERA AND TELESCOPE

- One of the Largest Binocular and Telescope Displays in the East
- Mail-Order or In-Store
- No Sales Tax!
- Used Scopes — Buy, Sell or Trade-In
- Knowledgeable, Personalized Service

Hours:
M-W 8:30-6
Th. 8:30-7
Fri. 8:30-6
Sat. 9:30-5

MONEY BACK 100% Satisfaction GUARANTEE

Toll-Free (800) 245-7963
www.riverscamera.com
454 Central Ave., Dover, NH 03820 Fax: (603) 742-5456

BIG EVENT:
RIVERS ASTRODAY
April 8, 2006
Seminars, Specials, Factory Reps. See website for details.

Nikon • Canon • Pentax • Minolta • Leica • Olympus • Kowa • Bushnell • Kendrick • JMI Accessories
ScopeTronix Accessories • Telrad • Losmandy • Vixen Products • Coronado • Large Book Selection

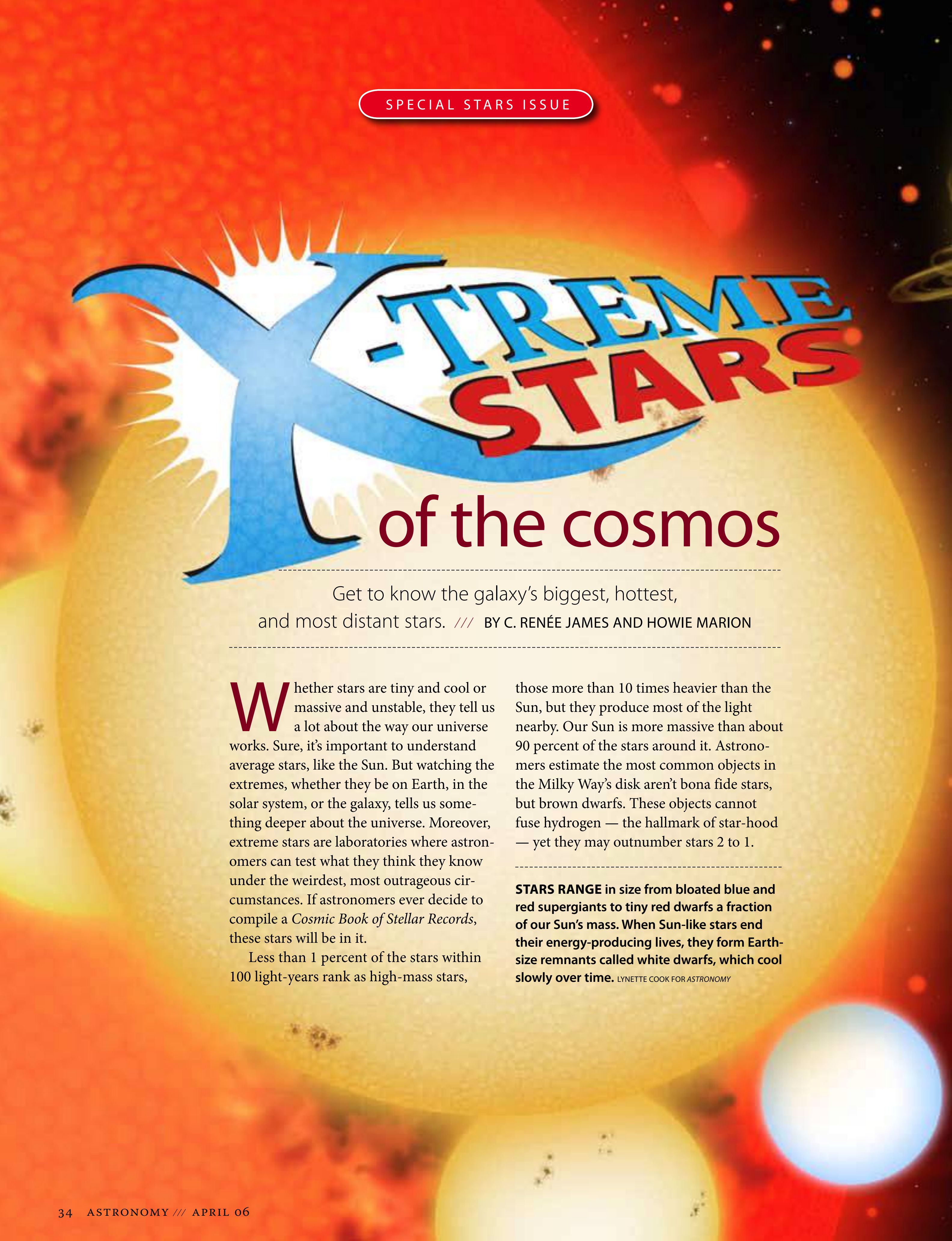
SPECIAL STARS ISSUE

X-TREME STARS of the cosmos

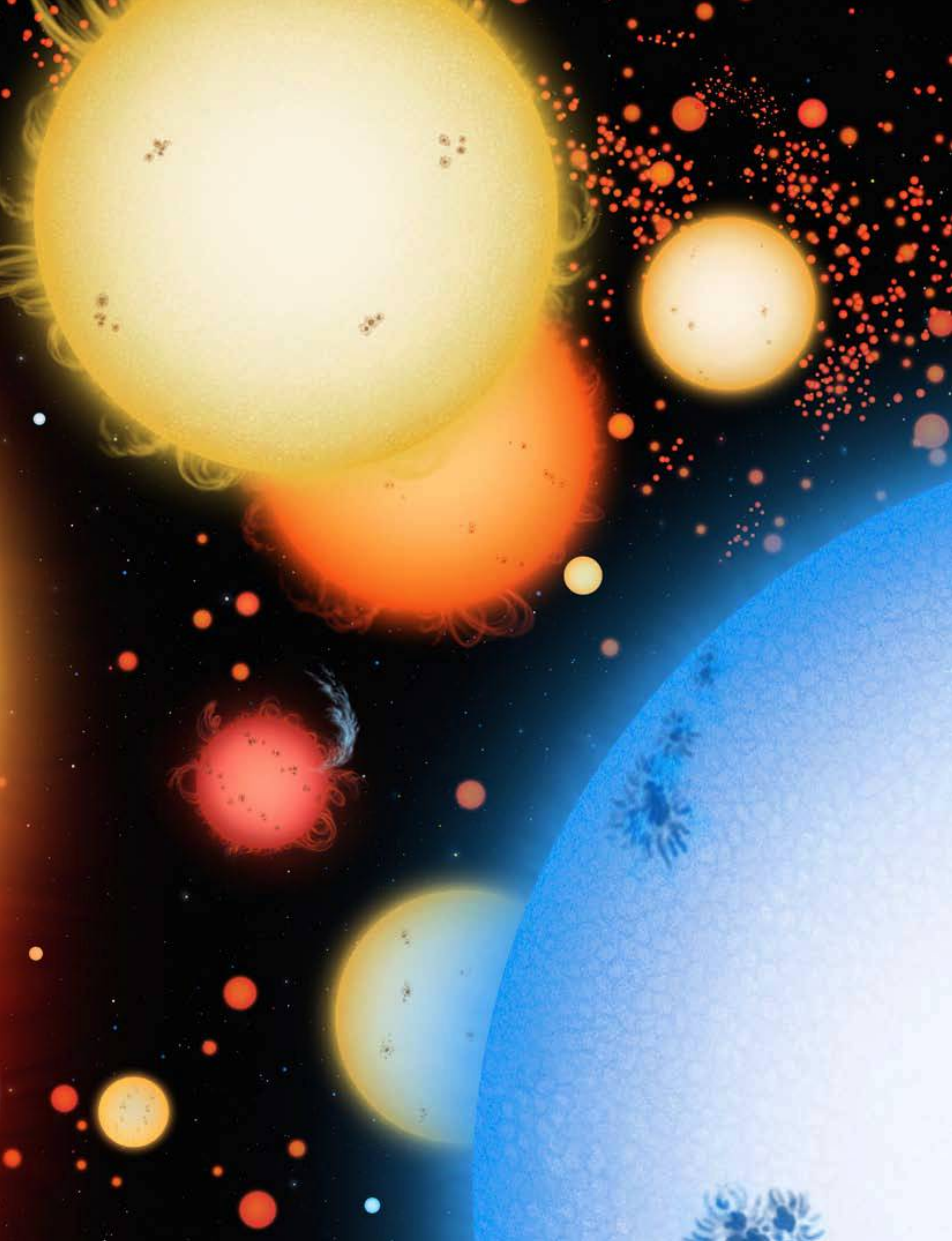
Get to know the galaxy's biggest, hottest, and most distant stars. /// BY C. RENÉE JAMES AND HOWIE MARION

Whether stars are tiny and cool or massive and unstable, they tell us a lot about the way our universe works. Sure, it's important to understand average stars, like the Sun. But watching the extremes, whether they be on Earth, in the solar system, or the galaxy, tells us something deeper about the universe. Moreover, extreme stars are laboratories where astronomers can test what they think they know under the weirdest, most outrageous circumstances. If astronomers ever decide to compile a *Cosmic Book of Stellar Records*, these stars will be in it.

Less than 1 percent of the stars within 100 light-years rank as high-mass stars, those more than 10 times heavier than the Sun, but they produce most of the light nearby. Our Sun is more massive than about 90 percent of the stars around it. Astronomers estimate the most common objects in the Milky Way's disk aren't bona fide stars, but brown dwarfs. These objects cannot fuse hydrogen — the hallmark of star-hood — yet they may outnumber stars 2 to 1.



STARS RANGE in size from bloated blue and red supergiants to tiny red dwarfs a fraction of our Sun's mass. When Sun-like stars end their energy-producing lives, they form Earth-size remnants called white dwarfs, which cool slowly over time. LYNETTE COOK FOR *ASTRONOMY*



X-TREME

MASS

MOST MASSIVE STAR KNOWN

Name: LBV 1806–20

Right ascension (R.A.): 18h08m40s

Declination (Dec.): –20°24'39"

Distance: 45,000 light-years

Surface temperature: At least 12,300 K (21,600° F) — more than twice the Sun's

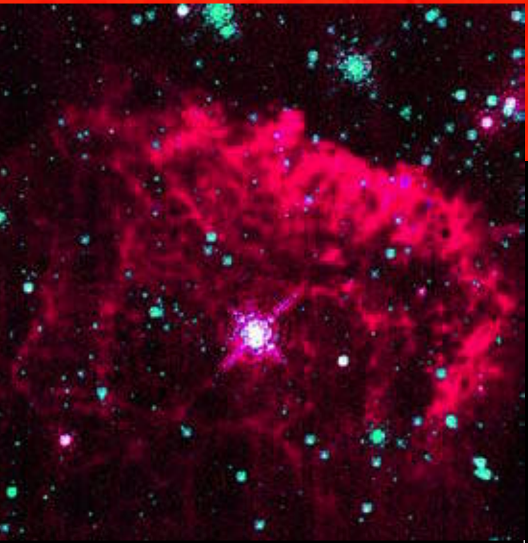
Mass: 150 to 200 Suns

Radius: Approximately 500 times the Sun's

Luminosity: 5 million Suns

Discovered: 1995, by Varsha P. Kulkarni and colleagues, initially noted as a counterpart to a soft-gamma-ray repeater

Caveat: May be a binary system or tight cluster. If so, then the Pistol Star, which is in the same mass range, wins the title.



THE PISTOL STAR, thought to weigh between 150 and 200 Suns, is a contender for the most massive star known. Named for the pistol-shape nebula it erupted, the Pistol Star unleashes as much energy in 6 seconds as our Sun does in a year. It's so big that, if placed at the center of our solar system, its surface would extend to Earth's orbit. The Pistol Star lies 25,000 light-years from Earth near the Milky Way's center. NASA/D. FIGER, UCLA

In the beginning

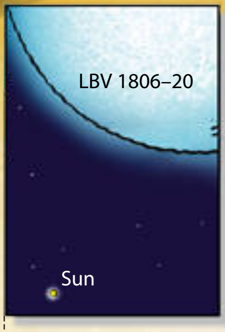
Stars first lit up our universe a few hundred million years after the Big Bang. They formed from the raw materials of hydrogen (75 percent by mass), helium (24 percent), and a pinch of lithium and beryllium (less than 1 percent). These high-mass stars then took on the task of creating the rest of the periodic table.

Boiled down to its essence, the recipe for stars throughout the universe's history is much the same as it is today. A large cloud of gas falls in on itself and *voilá* — a stellar hatchery forms. Some members will be high-mass stars, which will self-destruct in a cosmic heartbeat. Others, of more moderate mass, will survive for billions of years. Low-mass stars, by far the most common, make up for their stature with numbers and longevity. They'll fuse hydrogen fuel into helium for trillions of years.

Missing massives

The composition of the early universe was different than it is today. In just a few hundred thousand years, the first stars enriched their environs with elements heavier than helium, which astronomers refer to as metals. This modest change profoundly affected the lives of subsequent stellar generations.

Stars from the earliest epoch provide the light we see in the most distant galaxies, but the stellar demographics of these systems probably don't mirror what we find in our neighborhood. Astronomers think star-forming clouds containing low amounts of metals have difficulty creating low-mass stars. As a star is born, gravity pulls it together, but its own heat tends to puff it out and slow the process. Metals channel this heat outward efficiently, allowing the birth of low-mass stars. Without metals,



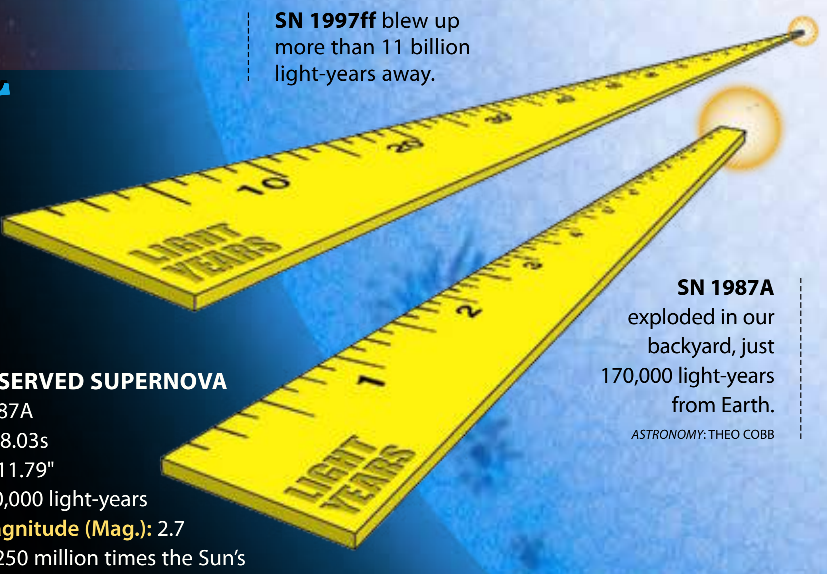
LBV 1806–20, more than 150 times the Sun's mass, holds the title for most massive star.

ASTRONOMY: THEO COBB

SOLAR MASSES
210
195
180
165
150
15
30
45
60
75
90
105
NO SPRINGS
- HONEST WEIGHT -

C. Renée James *is an associate professor of physics at Sam Houston University in Huntsville, Texas.* **Howie Marion** *studies type Ia supernovae at the University of Texas, Austin.*

X-TREME DISTANCE



SN 1997ff blew up more than 11 billion light-years away.

SN 1987A exploded in our backyard, just 170,000 light-years from Earth.

ASTRONOMY: THEO COBB

FARTHEST OBSERVED SUPERNOVA

Name: SN 1997ff
R.A.: 12h36m44s
Dec.: 62°12'45"
Distance: 11.3 ± 0.2 billion light-years
Luminosity: 2 billion times the Sun's
Discovered: 1997, by Ron Gilliland and Mark Phillips
Caveat: No longer visible. These objects show up only for a few months, and, even at peak brightness, it was approximately 24th magnitude.

NEAREST OBSERVED SUPERNOVA

Name: SN 1987A
R.A.: 5h35m28.03s
Dec.: –69°16'11.79"
Distance: 170,000 light-years
Apparent magnitude (Mag.): 2.7
Luminosity: 250 million times the Sun's
Discovered: February 23, 1987, by Ian Shelton at Las Campanas Observatory, Chile
Caveat: Closest supernova since the telescope's invention (1610). The progenitor star was Sanduleak –69° 202, a blue supergiant.

astronomers believe, most of the Sun's neighbors couldn't have formed.

The early universe's lack of metals figured in the birth of massive stars, too. A massive protostar could gain weight more rapidly in that environment than it can today. Astronomers think that, back then, stars could grow to masses 1,000 times greater than the Sun's before they tore apart. These supermassive stars eventually collapsed into black holes, taking virtually all of their synthesized elements along for the ride. Although these supermassive stars dominated the light output of the first galaxies, their role in the early universe's evolution is unclear. Moreover, astronomers aren't sure what kind of stars they're seeing when they look this far back in time. Does most of this light come from just a few supermassive stars? Or is a crowd of less extraordinary stars responsible?

Current telescopes can't resolve individual stars within those ancient galaxies, so astronomers must examine closer stars. Stars with masses above about 150 solar masses don't seem to exist locally. Why? Do supermassive stars die too quickly, so that the odds of seeing one close by are essentially zero? Does our galaxy's metal content allow star-forming clouds to fragment into many low-mass stars at the expense of massive ones? Do the metals in massive protostars interact so strongly with radiation that the stars shred themselves?

"Right now we don't know whether the observed mass limit is an intrinsic property of stars or the star-formation process, or whether it is imposed by the environment," says astronomer Sally Oey of the University of Michigan at Ann Arbor, whose team has completed a statistical analysis confirming the observed upper limit. Theorists, however, must still grapple with those numbers. "Understanding the basic parameters of the massive star population is essential," Oey says, because stars have always been the universe's consumers, producers, and recyclers.

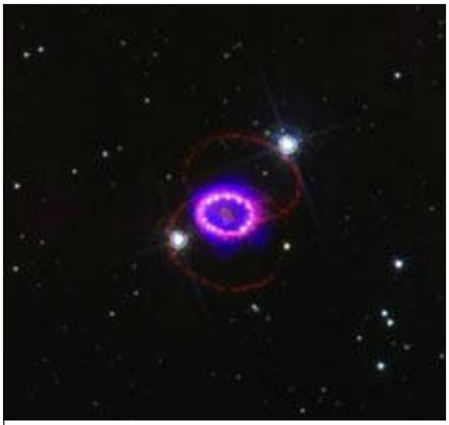
Low-mass stars — those with less than the mass of our Sun — make up the other extreme. Stars born with 60 to 80 percent of the Sun's mass in the first stellar generation would still be shining today. Despite their small masses, such stars are extremely fuel-efficient and can last tens of billions of years. The oldest ones would be the stellar equivalent of living fossils. Trouble is, astronomers don't think stars of such low mass could form in the extremely metal-poor environment of the early universe.

About 2.5 percent of the Sun's material is neither hydrogen nor helium, which indicates our star formed from gas processed by at least two earlier generations of stars. Astronomers have observed stars with metal abundances as low as 0.1 percent of the Sun's for decades. Most likely, such stars represent the second stellar generation. But with contributions from many supernovae, the exact demographics of that first generation have been difficult to unravel. For a long time, both theory and observation suggested astronomers wouldn't be able to find any stars with metal content less than 1⁄10,000 that of the Sun's.

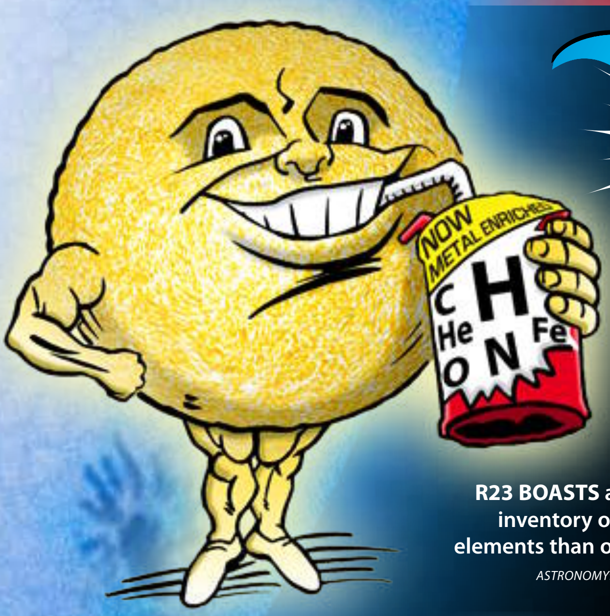
And then they did.

Stellar surprise

The 2002 discovery of HE 0107–5240, presented astronomers with clear evidence that low-mass stars can form in metal-poor clouds. In just 4 years, HE 0107–5240 has



SN 1987A still puts on a show for astronomers. Its blast wave is interacting with a ring of debris the star shed before it exploded. As the wave heats the material, million-degree knots set the ring aglow. NASA/STScI/CfA/P. CHALLIS



R23 BOASTS a better inventory of heavy elements than our Sun. *ASTRONOMY:* THEO COBB

HE 1327–2326 has only a fraction of the Sun's metals. It comes from an early stellar generation. *ASTRONOMY:* THEO COBB

X-TREME CHEMISTRY

MOST CHEMICALLY ENRICHED STAR

Name: R23 in the open cluster NGC 6791
Metal content: More than 4 times the Sun's
R.A.: 19h23m53s
Dec.: 37°46'18"
Mag.: 14
Distance: 14,000 light-years
Surface temperature: 4,600 K (7,800° F)
Mass: Approximately 1.2 solar masses
Radius: Approximately 25 times the Sun's
Luminosity: Approximately 250 times the Sun's
Discovered: 2003, by team led by Guy Worthey, Washington State University
Caveat: This star appears far more enhanced than its cluster siblings and deserves further study. Second place goes to HD 182572, with 2.5 times the Sun's metal content.

LEAST CHEMICALLY ENRICHED STAR

Name: HE 1327–2326, with $1/250{,}000$ the Sun's metal content
R.A.: 13h30m06s
Dec.: –23°41'54"
Mag.: 13.5
Distance: At least 4,700 light-years
Surface temperature: 6,200 K (10,700° F)
Mass: Sun-like, possibly smaller
Radius: Sun-like, possibly larger
Luminosity: At most 5 Suns
Discovered: 2005, by Anna Frebel and colleagues

been the subject of nearly 40 journal articles. They address everything from the mass range of the first stars, to the chemistry of the Milky Way's first supernova explosions, to how low-mass stars could form in the young universe. Since 2002, astronomers have found stars with even lower metal fractions (see "X-treme chemistry," above).

But if these stars formed, they also died. In doing so, they puffed out their gaseous envelopes, and their cores turned into white dwarfs. Pair up a white dwarf and a normal star, and you have a time bomb. As the normal star evolves, it will swell and donate material to its white-dwarf companion. This transfer of matter sets the stage for one of the most powerful explosions in the cosmos: a type Ia supernova.

Type Ia supernovae are brilliant beacons — astronomers can spot them billions of light-years away. Observations of type Ia supernovae have driven the recent acceptance of an accelerating cosmic expansion. But, from the perspective of extreme stars, spectra of these supernovae tell astronomers about the composition of the exploding white dwarfs and their companions. Of significance to cosmologists: Does composition affect the supernova's peak brightness and fade-out time? Could early type Ia supernovae be different from today's?

White dwarfs also help us trace our galaxy's history. Once blazing hot at more than 100,300 K (180,000° Fahrenheit), white dwarfs themselves have no additional power source, no ability to compress and heat any further (at least without help from a partner), and nothing left to do but cool off forever.

Don Winget at the University of Texas, Austin, is drawn to this research. "There is a straightforward relation between the age of a white dwarf and its luminosity," he says. Compared to other stars, white dwarfs are simple, Winget explains.

For the past decade or so, astronomers have searched for the coolest white dwarfs as clues to the ages of different galactic populations. Applying relatively basic astrophysical principles, astronomers find that white dwarfs in the Milky Way have been cooling down for the past 8 or 9 billion years. The current record holder is SDSS J1403, which glows faintly at a mere 4,300 K (7,200° F).

"Finding SDSS J1403 is like unearthing the oldest known fossilized bone of a prehistoric dinosaur," says the University of Chicago's Evalyn Gates, who discovered the star. "We have much to learn from these relics from the ancient universe as we seek to refine the picture they sketch out for us of the early galaxy."

Migrating worlds

Meanwhile, stars are born, live, and die. They scatter their elemental ashes into the galaxy, eventually enriching gas clouds enough that planets, and even life, become possible. The idea that stars like the Sun have planets was mere speculation 16 years

ago. Then, in 1995, Michel Mayor and Didier Queloz of Switzerland's Geneva Observatory confirmed the first extrasolar planet around 51 Pegasi, a star with essentially the same mass and temperature as our Sun. A team led by Geoff Marcy at the University of California, Berkeley, followed up with precise information about the planet: It's a gas giant with a Jupiter-like mass, and it orbits every 4 days.

How can a gas giant lie so close to its parent star? This made no sense with what we thought we knew about the formation and evolution of planetary systems. Dozens of subsequent discoveries confirmed the seemingly common existence of Jupiter-size planets practically skimming the surfaces of the stars they orbit. These planets spurred new theories of planetary migration to explain their locations and sizes.

Astronomers wonder if perhaps some condition within the star's natal cloud drives the process that allows giant planets to form so close to their stars. Metal-rich clouds seem to encourage not only the formation of lightweight stars, but also the development of close-in giant planets. Recent research suggests that, for the most part, stars with close-in giants also have metal concentrations some 60 percent higher than the Sun's.

And here we sit, on a planet orbiting the Sun — a star that is neither the most nor the least massive, neither the hottest nor the coolest. Our Sun is far from being the oldest star, and nearly as far from being the youngest. It holds a modest supply of goods manufactured by other stars, and its gas-giant planets haven't migrated far enough to disrupt the orbits of smaller, rocky worlds like Earth.

All in all, we should be thankful any *Cosmic Book of Stellar Records* lacks an entry for our Sun. ▣

ONLINE EXTRA Visit www.astronomy.com/toc for a list of extreme stars you can see.

X-TREME TEMPERATURE

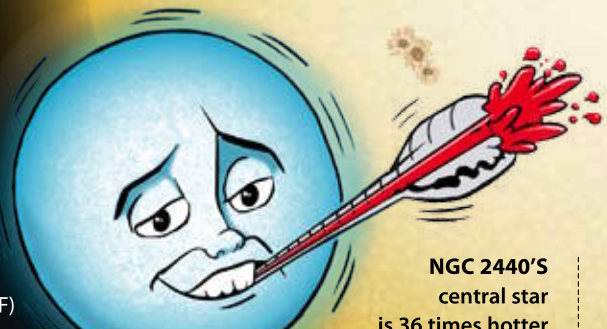
COOLEST WHITE DWARF KNOWN

Name: SDSS J1403
R.A.: 14h03m24.7s
Dec.: 45°33'33"
Mag.: 20
Distance: 145 light-years
Temperature: Possibly less than 4,300 K (7,200° F)
Mass: Approximately 0.6 Sun
Radius: Approximately 1/100 the Sun's
Luminosity: 0.00002 Sun
Discovered: 2004, Evalyn Gates and colleagues
Caveat: Don Winget and colleagues warn that current models cannot reproduce the spectra of these ultra-cool white dwarfs. Mukremin Kilic (University of Texas) warns, "We are clueless on the temperatures of these objects."

SDSS J1403'S TEMPERATURE tells astronomers how long the white dwarf has been cooling. This, in turn, helps narrow down the age of star clusters and the Milky Way as a whole. *ASTRONOMY*: THEO COBB

HOTTEST WHITE DWARF KNOWN

Name: Central star of NGC 2440
R.A.: 7h41m54.9s
Dec.: –18°12'29.7"
Mag.: 17.6
Distance: 7,100 light-years
Temperature: 211,000 K (380,000° F)
Mass: Approximately 0.6 Sun
Radius: 0.028 Sun
Luminosity: 1,100 Suns
Discovered: The planetary nebula, known since the 1800s, was included in the *New General Catalogue*. A team led by Michael J. Wolff at the Space Science Institute in Boulder, Colorado, used Hubble Space Telescope data to make the latest contributions in understanding the central star.



NGC 2440'S central star is 36 times hotter than our Sun. *ASTRONOMY*: THEO COBB

YOUNG PLANETARY NEBULA NGC 2440 shines by the light of its central star, the hottest white dwarf now known. NASA/HUBBLE HERITAGE TEAM (AURA/STScI)

SPECIAL STARS ISSUE

Live fast, die young

Astronomers don't understand massive stars — rare beasts with short lives but lasting impact. These 10 questions rank among the most baffling. /// BY YAËL NAZÉ

The universe continues to baffle the great minds of our age. Yet, ask most people where the deepest mysteries lie, and you're apt to hear discussions on the origin and fate of the cosmos, the nature of dark matter, and the existence of extraterrestrial life. Astronomers must have figured out all there is to know about mundane objects like stars, right?

Not so. These ubiquitous building blocks of galaxies still hold many secrets. The greatest questions surround the stars with the most mass. On a cosmic scale, these rare behemoths last only the blink of an eye. Yet, in their short lives, they forge heavy elements — the raw material for future generations of stars, planets, and perhaps life — and then eject them into the cosmos in titanic explosions.

Recently, Cássio Barbosa of Brazil's University of São Paulo and Donald Figer of the Space Telescope Science Institute in Baltimore surveyed their fellow researchers to find out the most pressing questions facing theorists and observers. Here are 10 topics that keep their minds busy:

Yaël Nazé *received her doctorate in astrophysics from the University of Liège (Belgium), where she studies massive stars and their relationship to the environment.*

ONLINE EXTRA Visit www.astronomy.com/toc to find out what other questions perplex astronomers who study massive stars.

BLUE LIGHT EMANATES from the massive young stars that reside near the Tarantula Nebula's center. NASA, N. WALBORN AND J. MAÍZ-APELLÁNIZ (STScI), AND R. BARBÁ (LA PLATA OBSERVATORY)

THE GAIA spacecraft will measure precise distances to 220 million stars, including — for the first time — high-mass stars.

ESA

1 How far away are massive stars?

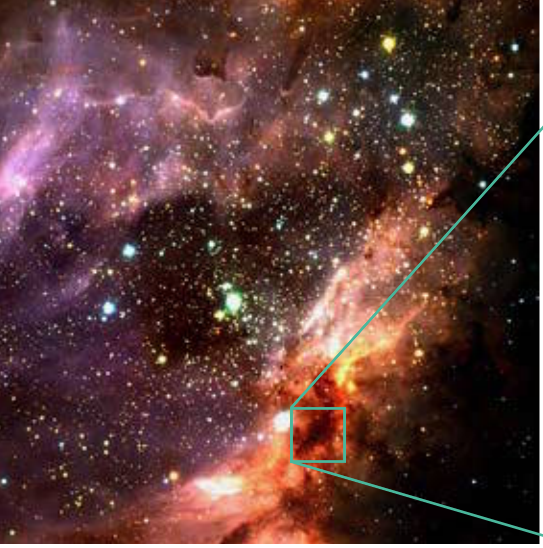
It's so simple a question, it seems extraordinary we don't yet know the answer. After all, astronomers have accurate distances to a host of low-mass and mid-size stars. The best method for getting reliable distances involves measuring the position of a nearby star relative to more distant objects from opposite sides of Earth's orbit. Simple trigonometry then converts the star's observed angular displacement into a distance.

Unfortunately, these angles are so small, the method can be applied only to the Sun's close neighbors. Before 1989, this technique had yielded just a few hundred precise distances. Things changed that year with the launch of the European Space Agency's (ESA) Hipparcos satellite. Today, astronomers have reliable distances to 20,000 stars out to a maximum distance of 300 light-years.

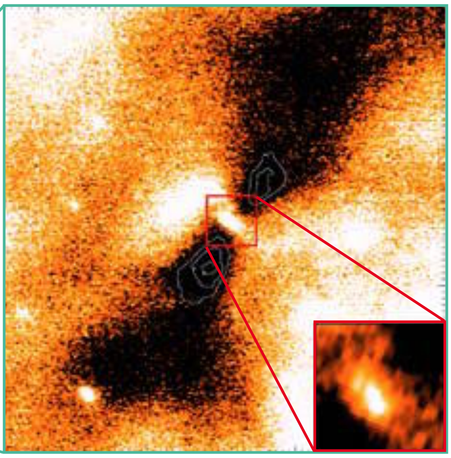
Yet, this seemingly large sample of solar neighbors does not contain a single massive star. So rare are these heavyweights that the nearest one lies more than 400 light-years away. Astronomers can only estimate the distances to these stars: The closest O-type star, Zeta Ophiuchi, lies somewhere between 417 and 509 light-years away; the nearest Wolf-Rayet star belongs to the binary system Gamma^2 Velorum and checks in at a distance of 740 to 975 light-years.

Without a precise distance, it's impossible to know a star's real properties, like luminosity, and this leads to uncertainty in theoretical models. Massive stars easily rank as the most luminous in the cosmos — the brightest outshine the Sun by a million times. And these are the only stars bright enough for us to see in distant galaxies. So, understanding massive stars better will improve our knowledge of extragalactic astronomy.

This first problem may be solved quickest. ESA plans to launch Gaia, a successor to Hipparcos, in 2011. This satellite, which will lie nearly a million miles beyond the Moon, will get accurate distances to 220 million stars out to a distance of 30,000 light-years. That's far enough to pinpoint a significant fraction of all the Milky Way's massive stars.



◀◀ **A CLUSTER OF MASSIVE STARS** forms from the gas and dust of the Omega Nebula (M17) in Sagittarius. Protostars lie embedded in a huge molecular gas cloud near the nebula's southwestern edge (box). ESO



◀ **A MASSIVE PROTOSTAR** inside the vast cloud grows as it accretes matter from a surrounding disk. The developing star currently contains about 20 solar masses, and the disk weighs in at more than 110 solar masses. ESO

2 How do massive stars form?

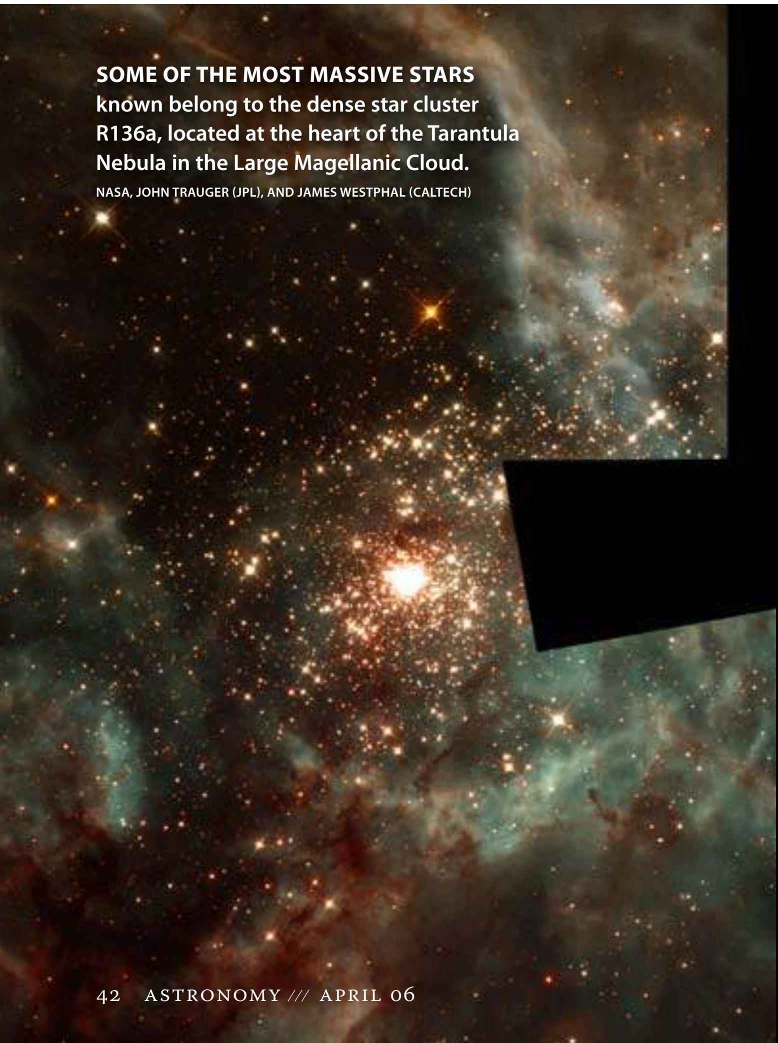
The birth of monster stars provokes heated quarrels among specialists. Two theories confront each other. In the first, massive stars form like their low-mass cousins. Gravity causes an interstellar gas cloud to collapse and fragment, with both big and small stars forming in the process.

The problem: Massive objects should start nuclear reactions long before they reach final form. The reactions emit intense radiation that should stop more matter from falling in. A slight alteration may save this idea. Scientists now suggest the largest fragments become mid-size protostars, each surrounded by an accretion disk. The growing stars gain weight by feeding off their disks. Observations have found at least one massive star, located in the Omega Nebula (M17), forming as this model predicts.

Other observations imply massive stars are born when smaller objects collide. Most big stars live in clusters, and the more stars a cluster contains, the more massive the largest stars are. X-ray observations reveal lots of low-mass stars near the massive objects. Could they be a food reservoir?

Computer simulations show collisions can be an effective method of creating massive stars. Nevertheless, not all massive stars belong to clusters. Were these solitary gems born in a different way or were they violently ejected from their birthplaces?

For the moment, astronomers have yet to reach a consensus. Some scientists think both processes could act simultaneously.



SOME OF THE MOST MASSIVE STARS known belong to the dense star cluster R136a, located at the heart of the Tarantula Nebula in the Large Magellanic Cloud.

NASA, JOHN TRAUGER (JPL), AND JAMES WESTPHAL (CALTECH)

3 What is a star's maximum mass?

Up until a decade or so ago, some researchers claimed they had discovered stars with extraordinary masses. For example, R136a — the central region of the star-forming Tarantula Nebula in the Large Magellanic Cloud (LMC) — was thought to be a single star containing 250 solar masses. However, the illusion has passed. Most of these mass estimates were done by indirect means. Better observations showed the apparently ultramassive stars are dense clusters of smaller stars possessing more reasonable masses.

Still, determining how much massive stars weigh proves difficult. The only reliable method involves studying binary-star orbits. An orbit's size and period depend on the stellar masses. To date, two binary pairs appear most promising. LH 54–425 in the LMC contains a star with approximately 50 solar masses and one with about 100. The Milky Way pair WR 20a contains two stars, each weighing about 80 solar masses. However, more massive stars may be out there. Some scientists think ultraluminous X-ray sources may contain black holes with masses higher than those of normal stellar black holes. Could they be born from the deaths of extremely massive stars?

Apart from direct observation, astronomers also wonder if a physical limit exists beyond which no star can form. If so, does the limit depend on the content of heavy elements in the gas from which the star formed, instabilities in the protostar's structure, dynamical processes within the cluster, or accretion problems?

4 What role did massive stars play after the Big Bang?

In the minutes following the Big Bang, the universe synthesized only a few light elements: hydrogen, helium, and lithium. From this mixture, the first stars were born.

Astronomers call this initial stellar generation "Population III." These peculiar, early stars played a crucial role in cosmic evolution because they sowed the universe with heavier elements and, thanks to their ionizing radiation, made the cosmos transparent again. These missing links between the Big Bang and today will help scientists understand the current face of the universe.

Theoretical models indicate these stars were born 100 to 250 million years after the Big Bang and each contained several hundred times the Sun's mass. These enormous objects died in gigantic supernova explosions that ejected all the elements these stellar "nuclear factories" had synthesized. If our bones contain calcium, our computers silicon, and our power plants uranium, thank these stars and their massive descendants. Nobody knows how such large objects formed, or even what properties they possessed. Of all the mysteries facing astrophysicists, the lives of Population III stars may be the hardest to solve because none of their kind survives.

THE FIRST STARS in the universe were massive ones that formed about 180 million years after the Big Bang. This computer simulation shows a central density concentration that will grow into one of these heavyweights. MATTHEW TURK AND TOM ABEL (KIPAC, STANFORD) AND GREG BRYAN (COLUMBIA)

5 How do massive binary stars form?

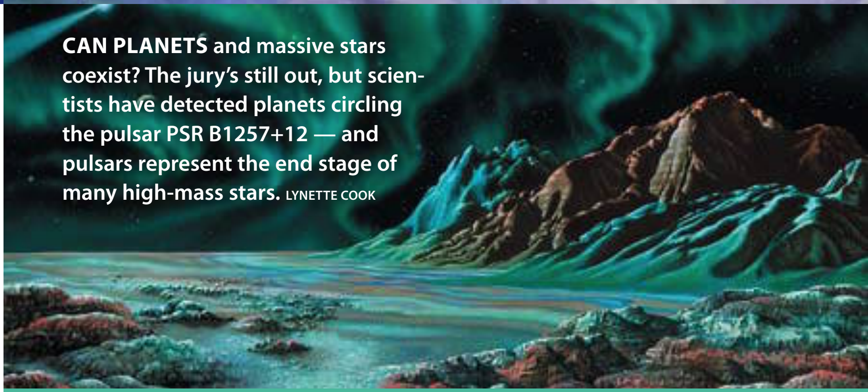
Massive stars often turn up in pairs, just like stars with lower masses. If theorists already have a hard time forming single massive stars, the problem becomes more acute with binaries.

Astronomers have developed several scenarios. *Capture* almost certainly plays a role. In a cluster, stars continually move around and occasionally graze each other. When the stars meet, a couple can form, although astronomers debate how frequently it occurs.

A second process involves *fission*. A star that rotates rapidly bulges at the equator. Crank the rotational speed high enough, and it can break in two. Unfortunately, only close binaries can form by fission, and some massive binaries have wide separations.

The final idea is *fragmentation* — a protostellar cloud breaks into several pieces that remain near one another. Or, a protostar might be surrounded by a massive accretion disk that coalesces into another star.

Although astronomers have yet to explain how massive binaries form, nature has found a way to create them. Massive pairs populate the galaxy, and some are true behemoths — each component of WR 20a contains approximately 80 times the Sun's mass.



CAN PLANETS and massive stars coexist? The jury's still out, but scientists have detected planets circling the pulsar PSR B1257+12 — and pulsars represent the end stage of many high-mass stars. LYNETTE COOK

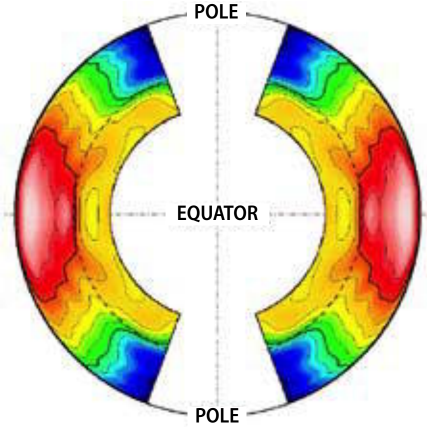
6 Can planets form around massive stars?

No planet has been found orbiting a massive star. But absence of evidence is not evidence of absence — particularly in this instance, because most planet searches have been conducted on Sun-like stars.

Planets form from circumstellar disks of gas and dust. But how long can such disks survive around massive stars? Plus, heavy stars exhaust their nuclear fuel in a few million years. Can planets form that fast?

Finally, conditions near a massive star are not friendly. These hot suns emit large amounts of ultraviolet radiation and ionized particles. The stellar winds carry away up to 10 billion times as much material as the solar wind at speeds of thousands of miles per second. So, even if planets do form around massive stars, they don't survive for long.

◀ **MAGNETIC FIELDS must be an important factor in how massive stars work, but how? As with rotation, detailed observations of stellar magnetic fields exist only for the Sun. Here, loops of hot gas in the Sun's corona follow magnetic field lines.** TRACE



▶ **ALL STARS ROTATE, but how do their interiors spin? Solar physicists have started probing the Sun's insides with helioseismology (in this illustration, red indicates fast rotation and blue, slow), but no one knows the role of rotation in massive stars.**
MICHAEL THOMPSON (UNIVERSITY OF SHEFFIELD)

7 *What role do rotation and magnetic fields play in massive stars?*

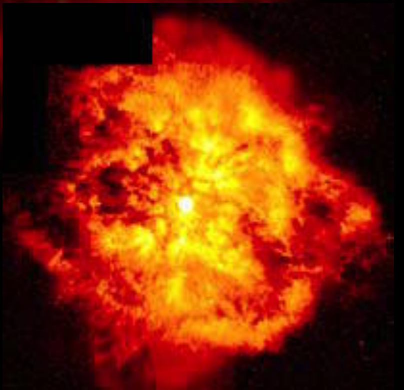
Current stellar models were not developed in a single day. These complex models already include a large number of parameters, but scientists have only begun to include two crucial factors: rotation and magnetic fields.

Astronomers see rotation everywhere in the universe. Planets and stars spin, galaxies rotate, and even galaxy clusters conduct their own celestial ballets. Researchers haven't been lazy by neglecting this factor in their stellar models, it's just that rotation creates theoretical and practical problems.

Although advanced computing power should soon overcome the numerical obstacles, other problems will still exist. For example, how do the interiors of massive stars rotate? Current research in astroseismology only begins to answer this question. The first measurement of the internal rotation of a star other than the Sun was made in 2003, and that was for a lower-mass object. Moreover, although astronomers agree rotation is a vital parameter, no one knows how it influences the births and evolution of massive stars.

Magnetic fields fall in the same category. They seem to be ubiquitous, showing up on Earth, Jupiter, the Sun, pulsars, and even in the interstellar medium. They almost certainly exist in massive stars. As with rotation, however, including this parameter in stellar models is a tricky business, and the first attempts have just been made. Will adding rotation and magnetic fields alter our ideas about massive stars?

LUMINOUS BLUE VARIABLE ETA CARINAE erupted in the 1840s, when it was the second-brightest star in the sky. The gas released then now largely hides the star, which tips the scales at around 100 solar masses. JON MORSE (UNIVERSITY OF COLORADO) AND NASA



GALE-LIKE WINDS blow at more than 100,000 mph from the surface of the massive Wolf-Rayet star WR 124, located 15,000 light-years from Earth.
YVES GROSDIDIER AND ANTHONY MOFFAT (UNIVERSITY OF MONTREAL), GILLES JONCAS (LAVAL UNIVERSITY), AGNES ACKER (STRASBOURG UNIVERSITY), AND NASA

8 *How do single massive stars evolve?*

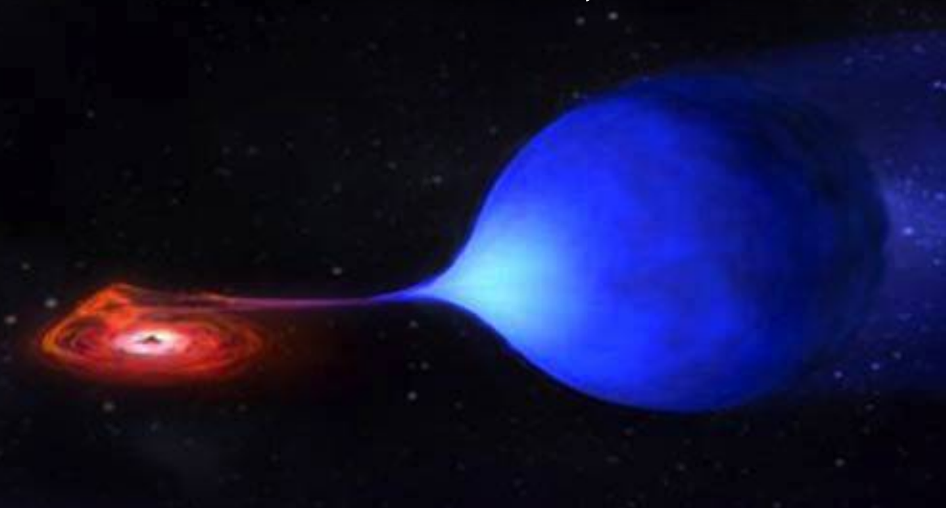
The lives of massive stars, although short, fuel intense debate. In broad outline, astronomers use the so-called Conti scenario to describe these objects' evolution. A massive star spends its adult life as an O-type star, with a fast and fairly dense stellar wind.

When the nuclear fuel starts to dwindle, the star evolves into either a red supergiant or a luminous blue variable (LBV) depending on its initial mass. During this stage, the star's stellar wind increases in density and slows dramatically — to only a few miles per second compared with thousands of miles per second for the adult star. LBVs even experience eruptions.

Next, the star becomes a Wolf-Rayet — the mass loss goes down, but the wind picks up. Throughout the star's life, the wind ejects matter and effectively peels the star. Layers with heavy elements gradually come to the surface. A Wolf-Rayet star becomes enriched first in nitrogen (a WN type), then in carbon (a WC type).

The Conti scenario may seem clear, but many details remain vague. The most contentious area concerns the LBV phase: What starts and stops LBV eruptions? Does the star's metal content play a role at the eruption's start? The most famous LBVs — Eta Carinae and HD 5980 — are binary systems; is this a necessity? What is the lowest stellar mass that can create such an event? Can a signature of this phase be seen once the star evolves into a Wolf-Rayet?

9 How do massive binaries evolve?



MATTER FLOWS from a massive blue star to a neutron star — the collapsed remnant of another heavy star. Material transfer in massive binaries affects the two stars' evolutions in ways still not understood. NASA

Massive binaries evolve in even more complex ways than single objects because the components interact throughout their lives. A companion's presence affects many stellar properties. For example, a massive companion can tidally deform a star so it's not spherical anymore. The neighbor's presence also changes each star's rotation. In a binary system, the stars' rotation periods often equal their orbital periods, so each star shows the same face to its companion throughout the orbit.

Even more complex phenomena take place. In massive binaries, the dual stellar winds collide, generating intense X-ray emission and changes in the system's optical spectrum. Astronomers are just beginning to study these effects. The space mates likely also exchange matter, with the cannibal partner sucking up its companion's wind or perhaps even part of its surface. What would happen if the more massive and evolved star suddenly became the less massive?

Even if nothing much happens to the system during the stars' lives, what if one of the partners suddenly dies? Can the system survive a supernova explosion? And, if so, how would a binary system composed of a normal massive star and either a neutron star or black hole evolve? Studies show that a compact object can spiral toward its companion and might even venture *inside* the other star. How would that situation change the other star's evolution?

Astronomers have found binary systems comprising two pulsars, so we know massive binaries can survive. But there's still a long way to go before we understand how systems reach such an end.

10 How do massive stars die?

NASA, ESA, AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

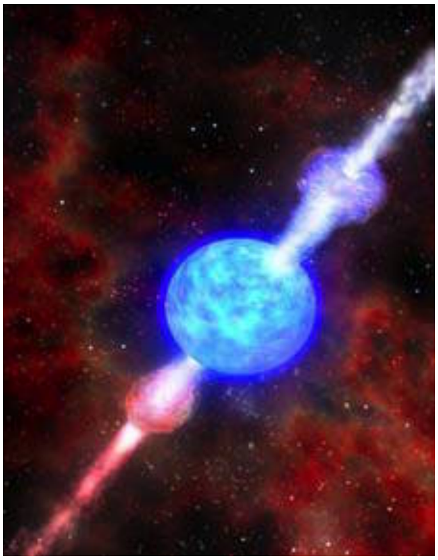
◀ **A CHAOTIC MESS OF GAS AND DUST expands in supernova remnant N 63A in the Large Magellanic Cloud. Most massive stars die in supernova explosions, although the exact mechanism remains murky.**

If Sun-like stars die rather quietly, massive stars end in cataclysm — a supernova explosion announces the death to the entire galaxy and beyond. Yet, forensic astronomers have questions about this process.

A massive star explodes after it exhausts the nuclear fuel in its core and no longer generates energy to support the weight of the star's outer layers. The core collapses and generates a shock wave that should blow apart the star's outer layers. Despite years of theorists' efforts, however, computer models still can't reliably convert the collapse into an explosion.

Gamma-ray bursts — the most powerful cosmic explosions — raise another question. Astronomers have shown that some of these bursts are linked to the deaths of massive stars. But no one knows how this happens or what differentiates a star that ends with a gamma-ray burst instead of a classical supernova.

After the supernova, two things remain: hot gas in the form of an expanding supernova remnant, and a compact object. Is the mass of the pre-supernova stellar core the only factor that determines whether the compact object is a black hole or a neutron star? And is it possible the explosion can totally rip apart the core, so that no corpse is left behind?



NRAO/AUI AND DANA BERRY (SKYWORKS DIGITAL)

▲ **A DYING MASSIVE STAR ejects a burst of gamma rays. Astronomers are trying to figure out what differentiates a gamma-ray burst from its more common counterpart: a supernova explosion.**

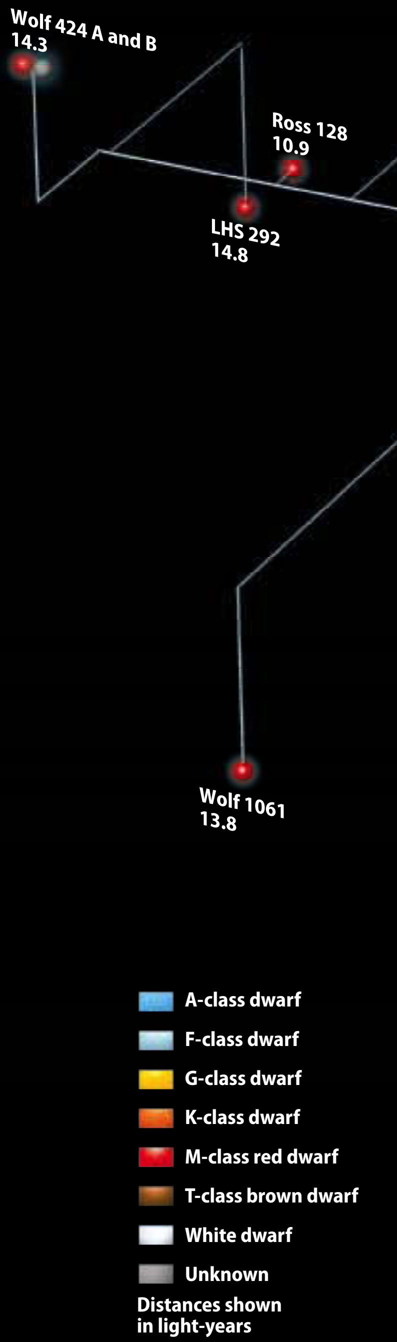
SPECIAL STARS ISSUE

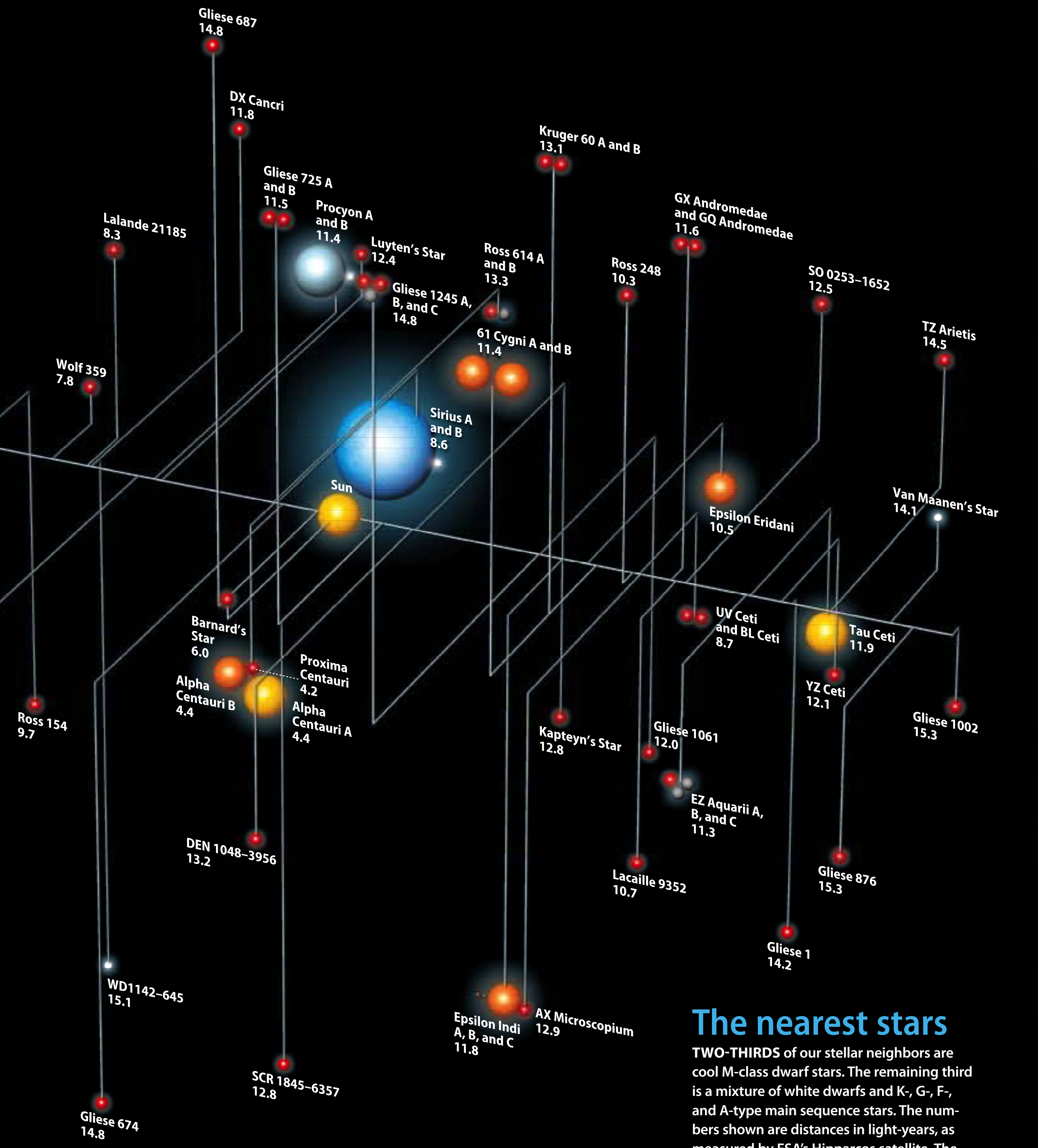
Meet the neighbors

The nearest stars hide secrets that could help astronomers learn more about our Sun's place in the galaxy. /// BY JAMES B. KALER

Most of the space in the Milky Way Galaxy can be pretty lonely — a dull, dark void. But our own neighborhood stands out as among the more intriguing places in the universe. Recently, with new telescopic technologies, astronomers have made big strides toward finding all our stellar neighbors. Knowing the stellar cast, they can then project this information into the galaxy at large to help us learn how stars, and even planets, are born

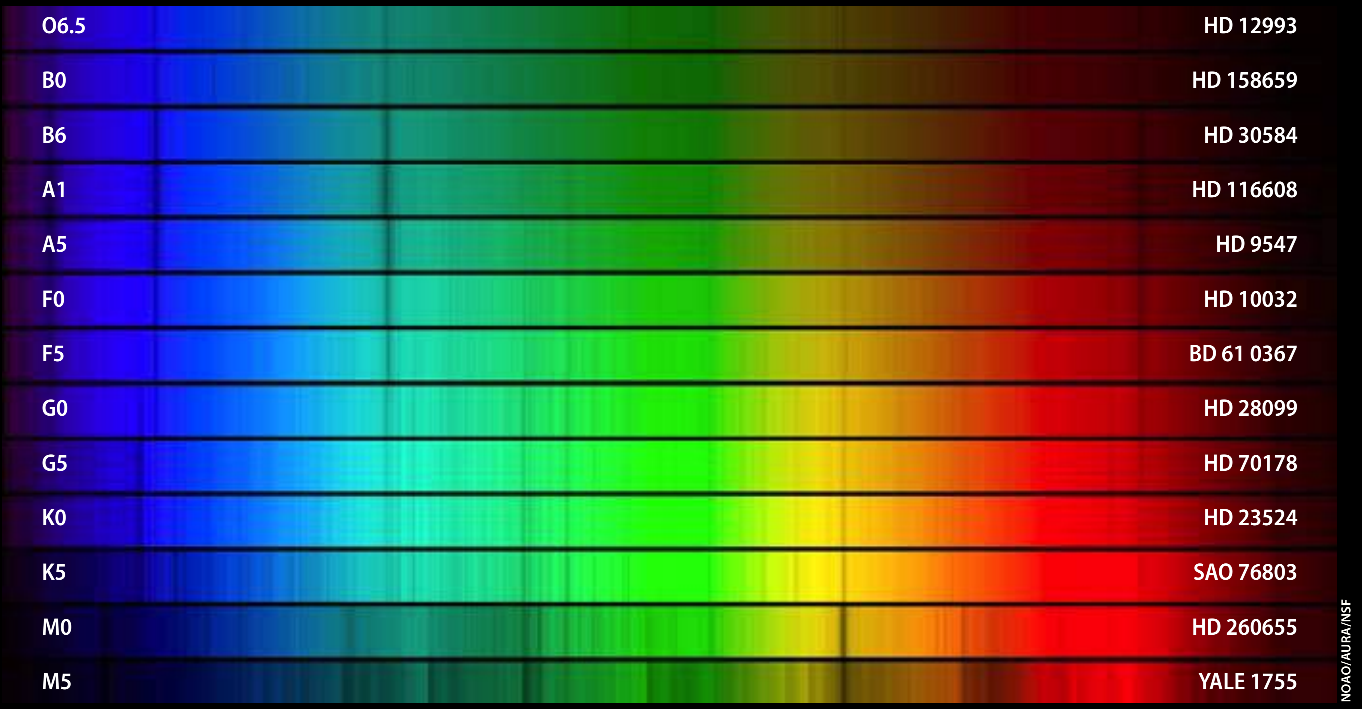
James B. Kaler *is a professor emeritus of astronomy at the University of Illinois, Urbana-Champaign. He is the author of* The Hundred Greatest Stars *(Copernicus Books, 2002).*


Wolf 424 A and B
14.3
Ross 128
10.9
LHS 292
14.8
Wolf 1061
13.8
A-class dwarf
F-class dwarf
G-class dwarf
K-class dwarf
M-class red dwarf
T-class brown dwarf
White dwarf
Unknown
Distances shown in light-years


Gliese 687
14.8
DX Cancri
11.8
Kruger 60 A and B
13.1
Gliese 725 A and B
11.5
Procyon A and B
11.4
Lalande 21185
8.3
Luyten's Star
12.4
GX Andromedae and GQ Andromedae
11.6
Ross 614 A and B
13.3
Ross 248
10.3
Gliese 1245 A, B, and C
14.8
SO 0253–1652
12.5
61 Cygni A and B
11.4
TZ Arietis
14.5
Wolf 359
7.8
Sirius A and B
8.6
Sun
Epsilon Eridani
10.5
Van Maanen's Star
14.1
UV Ceti and BL Ceti
8.7
Tau Ceti
11.9
Barnard's Star
6.0
Proxima Centauri
4.2
Alpha Centauri B
4.4
Alpha Centauri A
4.4
YZ Ceti
12.1
Ross 154
9.7
Gliese 1002
15.3
Kapteyn's Star
12.8
Gliese 1061
12.0
EZ Aquarii A, B, and C
11.3
DEN 1048–3956
13.2
Lacaille 9352
10.7
Gliese 876
15.3
Gliese 1
14.2
WD1142–645
15.1
Epsilon Indi A, B, and C
11.8
AX Microscopium
12.9
SCR 1845–6357
12.8
Gliese 674
14.8

The nearest stars

TWO-THIRDS of our stellar neighbors are cool M-class dwarf stars. The remaining third is a mixture of white dwarfs and K-, G-, F-, and A-type main sequence stars. The numbers shown are distances in light-years, as measured by ESA's Hipparcos satellite. The stars' sizes are scaled relative to each other, not to the distances between them. All stellar data are from the Research Consortium on Nearby Stars (RECONS). *ASTRONOMY*: ROEN KELLY



NOAO/AURA/NSF

ONE WAY to classify stars is by their absorption spectra. Each element absorbs light at wavelengths specific to that element and its atomic composition. The result is black lines on color spectra. Here are examples of different spectral types, each associated with a specific star.

ORGANIZING STARS

If you spread starlight into a rainbow — a spectrum — from violet through red, you will see absorption lines cutting out narrow bands of color. Each line is produced by a specific atom or ion.

More than a century ago, stars were organized into classes O, B, A, F, G, K, and M according to the lines present in their spectra. Astronomers later realized this scheme corresponds to a temperature scale that runs from 50,000 Kelvin (90,000° F) at the top (class O) to a bit above 2,000 K (3,100° F) at the bottom (class M). In the past few years, astronomers have added cooler classes (L and T) with surface temperatures down to hundreds of Kelvin.

Each class is divided into 10 parts from warm to cool; the Sun is in the middle at class G2.

Astronomers also organize stars by their current state in their life cycles. Ordinary "dwarfs" like the Sun — which are supported by the internal fusion of hydrogen into helium — lie on the main sequence line. Their masses range from over 100 times a solar mass in class O to just under one-tenth in M. The energy emitted from main sequence stars ranges from millions of times more luminous than the Sun — in class O — to 10,000 times less — in class M.

Beneath class M on the Hertzsprung-Russell classification diagram are "substars." These are class-L and -T brown dwarfs that cannot fuse hydrogen and have masses close to those of planets. In general, the lower a star's mass, the longer its life as a dwarf. Life spans of dwarf stars range from a few million years to trillions of years.

When the hydrogen fuel runs out, stars begin to die. Lower-mass stars, up to about 10 times that of the Sun, expand to become luminous "giants" — with radii comparable in size to the orbits of the inner planets — as they burn their helium into carbon and oxygen. They then lose most of their mass through winds. Their remains are dim white dwarfs, dead balls of carbon and oxygen about the size of Earth with average densities of 15 tons per cubic inch.

High-mass stars become ultraluminous supergiants with radii similar to Jupiter's orbit. They fuse their cores into iron and collapse to create supernovae. Their cores are left as either neutron stars with densities a million times those of white dwarfs or even black holes so dense that light cannot escape. — *J. K.*

and live out their lives. As a result of these studies, astronomers are now learning how our own Sun fits into the overall picture.

Neighborhood cliques

If we define our galactic neighborhood as a sphere just over 30 light-years across and centered on the Sun, it extends to the next nearest planetary system relatively similar to ours. Within this sphere lie 59 stars (including our Sun), which means our neighborhood has a density of 0.0039 star per cubic light-year.

Nature, however, likes to make doubles and multiples. While there may be 59 stars, there are only 42 star systems: 18 stars are in binaries, and 12 are in triples, which leaves only 29 in single-star systems. After accounting for the multiples, the density drops to 0.0028 system per cubic light-year.

Double stars are among the most important of astronomical objects — analyzing their stars' orbits reveals stellar masses. Fifty percent of local stars have companions, similar to the proportion observed over greater distances. In reality, the figure probably is higher because some dim companions surely are hiding in the glare of their mates. Quadruple and higher systems are rare, the nearest lying 19 light-years away.

Local star systems each have some 350 cubic light-years to roam around in and, thus, are on average very far apart. (Note:

All distances mentioned are from the European Space Agency's Hipparcos satellite.) The closest member of the Alpha Centauri triple, the nearest system to us, is 4.2 light-years away. For a sense of scale, 4 light-years is 27 million solar diameters, or 6,400 times the distance between the Sun and Pluto. If you put a marble on the ground to represent the Sun, the three stars of Alpha Centauri would comprise two marbles and a ball bearing 250 miles away. Stars in our neighborhood have a lot of empty space between each other; they will not collide.

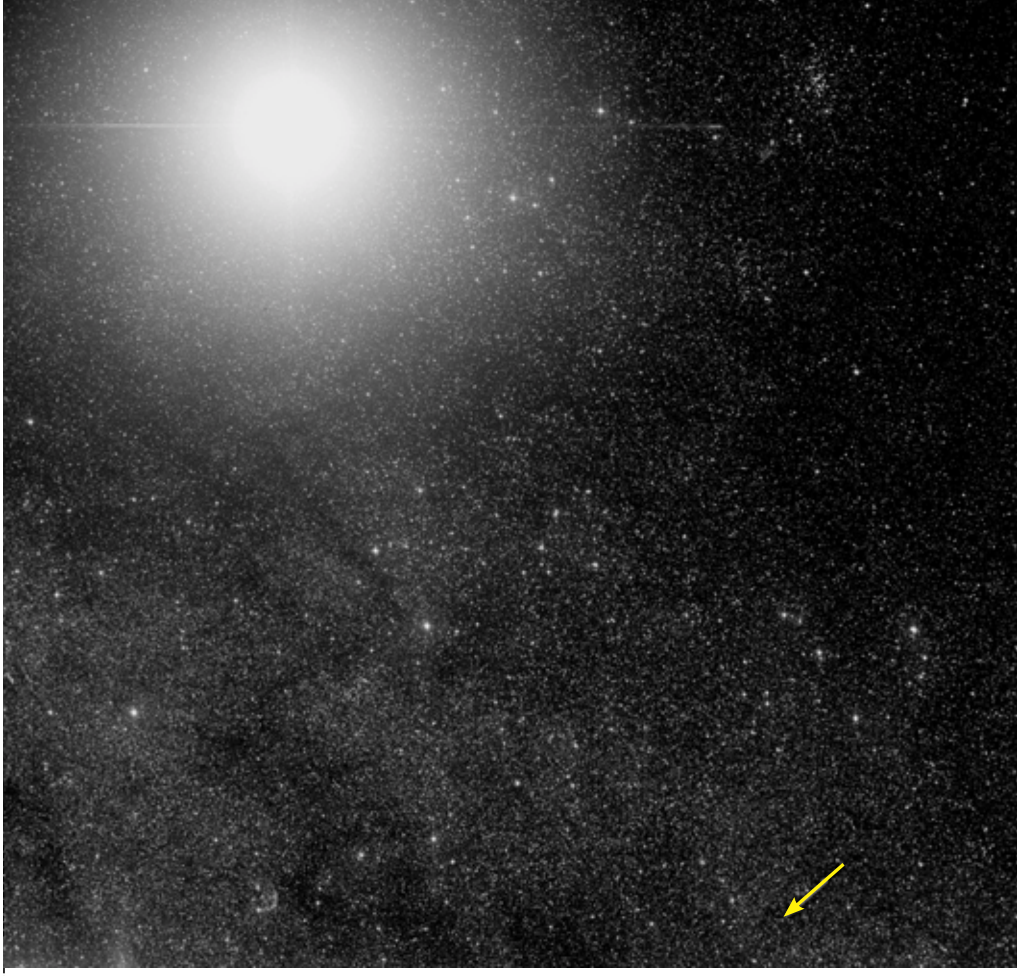
But that's not the astonishing part. Within 15 light-years, *no* high-mass class O or B stars exist. The closest B star — Regulus — is 78 light-years away, and the nearest O star is about 500. Neither does our designated sphere contain giants or supergiants. At 34 light-years, the nearest giant is Pollux. The closest supergiant, Betelgeuse, lies at an uncertain 400 light-years. Every star within 15 light-years from the Sun is a dwarf!

We do, however, see a run-of-the-mill A star, Sirius, at 8.6 light-years that has 22 times the visual solar luminosity. One cooler F star, Procyon, is 11.4 light-years away and is at least on its way to becoming a giant.

The cooler the stars we look at, the higher the numbers. Our neighborhood has three G-class stars: the Sun, the brightest member of the Alpha Centauri system, and Tau Ceti (11.9 light-years). Next cooler is the K class, which contains five stars. This group includes the second-brightest member of the Alpha Centauri system and the 61 Cygni double — the first stars whose distances (11.4 light-years) were known. In fact, the 61 Cygni system contains the coolest main sequence stars bright enough to be seen with the naked eye (you still need a telescope to resolve them from each other).

Almost two-thirds of nearby stars — 38 of them — are cool class-M red dwarfs with masses under half the Sun's. Not one of these stellar microbes is visible to the naked eye: The brightest glows at 7th magnitude. The nearest star to us belongs to this class: 11th-magnitude Proxima Centauri, the third member of the Alpha Centauri triple. This star is on the sunward side of its million-year orbit about the inner pair, and is, thus, about 10,000 Astronomical Units (AU, the distance between the Sun and Earth) closer to us, or 250 times the Sun-Pluto distance, than the brighter pair.

Two of our locals are even cooler T-class brown dwarfs, and both of them belong to

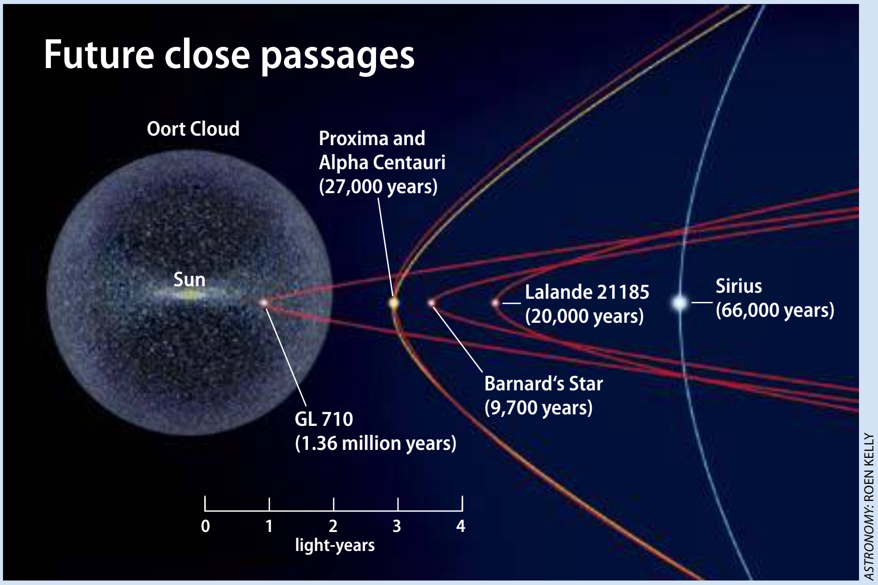


THE SUN'S NEXT-DOOR NEIGHBOR, **the Alpha Centauri triple system, contains two Sun-like stars and a red dwarf. Alpha Centauri A and B (top left) are overexposed in this image so the third member, Proxima Centauri (arrow) is visible.** EUROPEAN SOUTHERN OBSERVATORY

/// SPECTRAL CLASSES

Spectral type	Color	Temperature* (Kelvin)	Spectral lines
O	Blue	31,000–49,000	Ionized and neutral helium, weaker hydrogen
B	Blue-white	10,000–31,000	Neutral helium, hydrogen
A	White	7,400–10,000	Strong hydrogen, some ionized metals
F	White-yellow	6,000–7,400	Weaker hydrogen, ionized calcium and iron
G	Yellow	5,300–6,000	Weak hydrogen, neutral and ionized metals, especially calcium
K	Orange	3,900–5,300	Neutral metals, sodium, weak hydrogen
M	Red	2,200–3,900	Neutral metals, molecules, little hydrogen
L	Red-infrared	1,200–2,200	Hydrides, water, alkali metals
T	Infrared	Less than 1,200	Methane, water, alkali metals

*Temperatures are for main sequence dwarf stars; the temperatures of giants and supergiants of the same spectral type may differ.



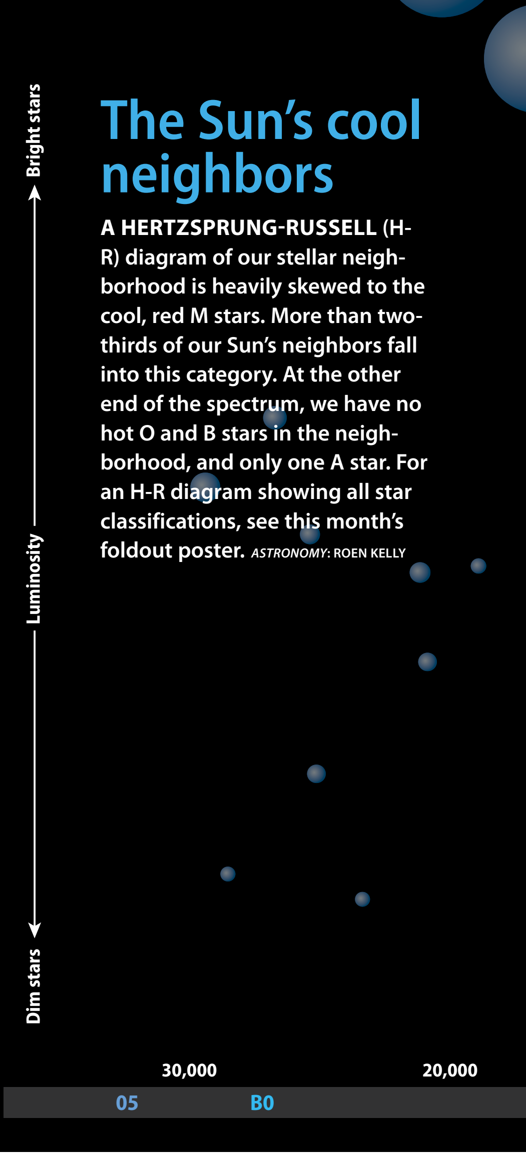
ASTRONOMY: ROEN KELLY

MANY NEARBY STARS will pass close to the Oort Cloud, but only one will move through it. Gliese (GL) 710, in 1.36 million years, will likely gravitationally perturb millions of comets, sending a sizable number on a potential collision course with Earth.

CLOSE STELLAR ENCOUNTERS

Our galaxy is in constant transition, and nearby stars present a few possible dangers. As stars orbit the galaxy, they constantly change positions relative to each other. Someday, a supergiant will invade our neighborhood, and, at Alpha Centauri's distance, it could shine with the light of 20 Full Moons. Even at 30 light-years, were it to explode, the results could severely damage Earth's atmosphere and alter life processes. Radioactive isotopes in Earth's ocean beds confirm that such an event has actually happened.

And don't discount the potential effects of red dwarfs. The Sun is surrounded by trillions of comets that were ejected from the early solar system. They form the Oort Cloud, which extends a good part of the way to Alpha Centauri. While local stars don't collide, they can still come close to each other. In a million years or so, Gliese 710 (now 63 light-years away) will come within a light-year of us. Such a close passage could gravitationally affect the Oort Cloud and cause a rain of comets that could impact Earth. — *J. K.*



The Sun's cool neighbors

A HERTZSPRUNG-RUSSELL (H-R) diagram of our stellar neighborhood is heavily skewed to the cool, red M stars. More than two-thirds of our Sun's neighbors fall into this category. At the other end of the spectrum, we have no hot O and B stars in the neighborhood, and only one A star. For an H-R diagram showing all star classifications, see this month's foldout poster. *ASTRONOMY:* ROEN KELLY

the Epsilon Indi system (11.8 light-years). They are so cool — barely warmer than a self-cleaning oven — that they radiate mostly infrared light. We still do not know just how many T-class dwarfs exist. Only in the past few years, with greatly improved infrared detectors, have they been found. Now, so many are cataloged that astronomers needed two new spectral classes for them: L and dim T.

Four other neighbors are, not surprisingly, white dwarfs — cinders of Sun-like stars. Two of these white dwarfs are dim companions to Sirius and Procyon.

The remaining five stars are mysteries, their characteristics unknown.

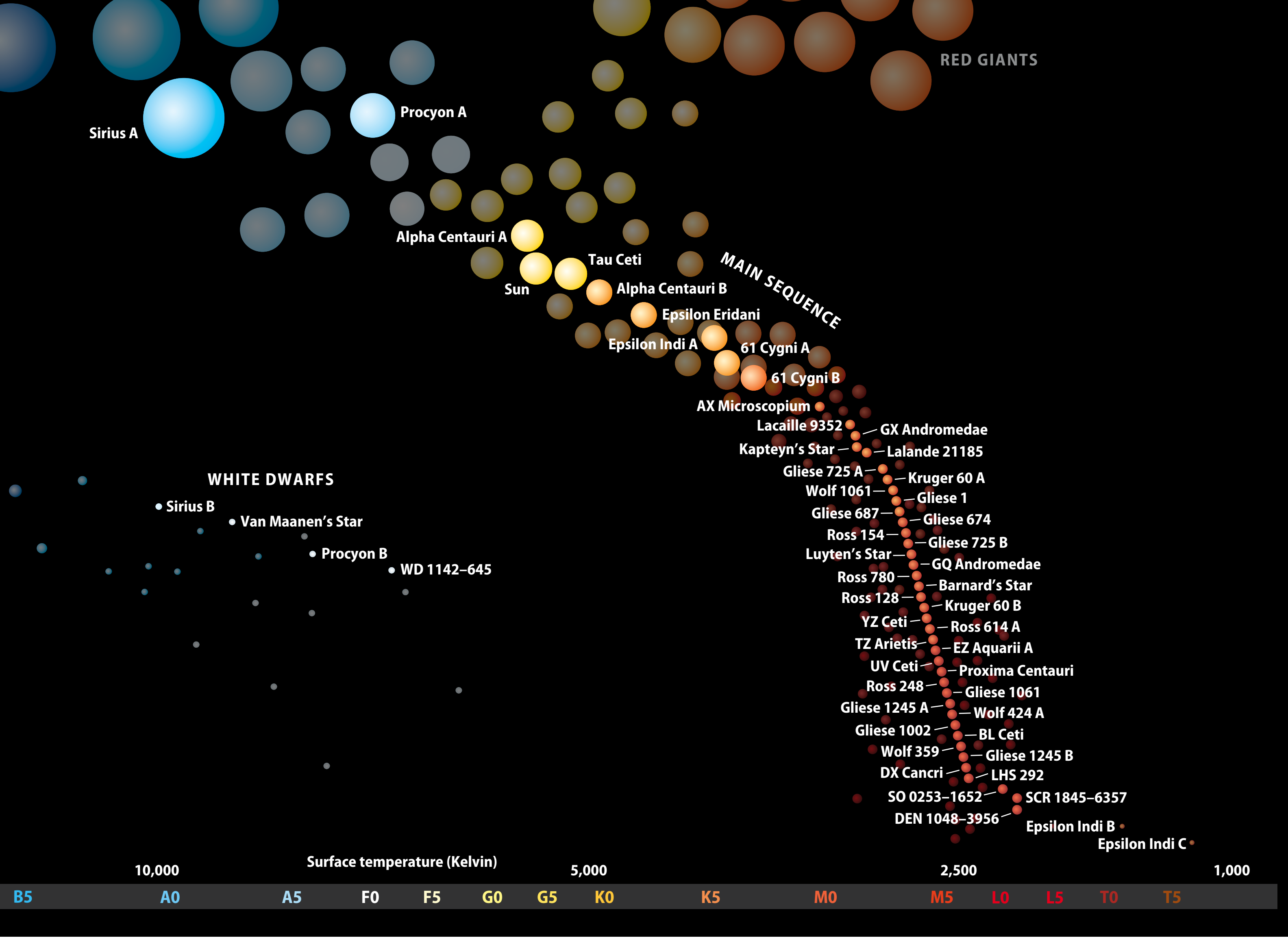
Roll call

The individual members of these groups have their own characteristics. Sirius is the closest "metallic" star (one with odd metal patterns, usually low in calcium and scandium, and high in copper, zinc, and other heavier elements). This unusual chemistry is caused by diffusion of chemical elements. Some elements settle in the star's core under gravity, others move upward by radiation. Sirius B, the accompanying white dwarf to A-class Sirius, used to be the dominant star, but it's 10,000 times fainter now and difficult to see (as is Procyon's companion).

When astronomers study the neighbors, Alpha Centauri usually takes center stage, and we neglect the second closest, Barnard's Star. Only 6 light-years away, this red dwarf holds the record for highest proper motion: It zips across the sky at 10" per year. The star's proper motion, combined with the 67 miles per second (108 kilometers per second) velocity toward us (deduced from Barnard Star's spectrum) gives the star a total speed of 87 miles/s (140 km/s) relative to the Sun. That's 10 times the speed of a normal star.

And this speed is slow compared to Kapteyn's Star, another red dwarf 12.8 light-years away. It's moving twice as fast (see "Fugitive from the galaxy's edge," *Astronomy*, January 2006, for more). Most local stars, including the Sun, are in a circular orbit around the galaxy's center. Barnard's and Kapteyn's, however, are tourists from the Milky Way's halo that are just passing through. Their high relative speeds are caused by very different galactic orbits.

Many red dwarfs have powerful magnetic fields that, like the Sun's, collapse to produce bright, localized stellar flares. Unlike the Sun's version, however, red-dwarf flares can temporarily double a star's brightness. Among the best known are Proxima Centauri and UV Ceti, the latter lying in a binary system 8.7 light-years away. Such flares are visible across the electromag-



netic spectrum, from X ray to radio, and can be fun for patient observers to spot.

Forty years ago, astronomer Frank Drake thought we might find intelligent signals from possible planets belonging to class-G Tau Ceti.

Another candidate, class-K Epsilon Eridani (10.5 light-years), appears to have a planetary system. With a mass slightly larger than Jupiter's, Epsilon Eridani's planet orbits in 6.9 years while moving wildly between 1.2 and 5.3 AU from its star. The planet is inhabitable. Such planets cannot be directly observed but are instead detected through their gravitational effects on their hosts. A thick disk of dusty debris surrounds Epsilon and is similar to the Kuiper Belt of small objects outside Neptune's orbit.

At the end of the tour is Ross 780 (Gliese 876), an M4 dwarf 15.3 light-years away that has three planets. Even though the planets are oddballs, their number and range in mass are similar to what we find in our solar system. The outer two have masses 2.5 and 0.7 times that of Jupiter. Unlike our giant planets, however, they are near the star, at 0.21 and 0.13 AU. This is considerably closer than Mercury is to the Sun (0.39 AU). As a result, they orbit in only 60.9 and 30.1 days. They are gravitational captives of each other; the outer planet orbits the star in twice the time it takes the inner. (Neptune has much the same relationship with Pluto; Neptune goes around the Sun 3 times for every 2 Pluto orbits.)

Except for some low-mass planets orbiting neutron stars (which are far away from our neighborhood), Ross 780 is home to the smallest planet yet found — just 9 Earth masses. But you wouldn't want to live there. A mere 0.021 AU (4.5 solar radii) from the star, the planet has a "year" of 1.9 days. From the planet, its sun would be more than 10° across in the sky (20 times the apparent diameter of our Sun from Earth) and would shower the planet with the energy of 30 Suns, most of that energy in the infrared.

DEFINING DISTANCES

Astronomers could measure the distances to stars in miles, but the numbers get really big. Instead, they use the light-year, the distance light travels in a year. The universe's top speed is the speed of light: 186,282 miles per second. The 31.56 million seconds in one year means one light-year stretches for 5.87 trillion miles (roughly the distance the U.S. population drives annually). The fundamental unit in astronomy, the Astronomical Unit (AU), is the average distance between Earth and the Sun: 93.2 million miles. This makes the light-year 63,240 AU long, just a bit short of the number of inches in a mile. — *J. K.*

Given these conditions, it's unlikely life exists on such a planet. But who knows? We can't help but wonder if the Sun's nearest stellar neighbors harbor neighbors of a different sort, some perhaps like Earth.

BY MARTIN RATCLIFFE AND ALISTER LING

APRIL 06

The setting stars of winter provide one last hurrah as the Moon skates through the Pleiades star cluster. Later in the month, a waning crescent Moon hardly hinders the Lyrid meteor shower.

The Moon caresses the Pleiades

No fooling — on April 1, you can experience one of the most beautiful conjunctions the sky can deliver. Around 7 P.M. local time, some 45 minutes after sunset, look west to see a perfect "old Moon in the new Moon's arms." Point your binoculars at it to reveal a stunning sight: the bright Pleiades star cluster sparkling like a clutch of tiny diamonds accenting the primary jewel.

The ashen light filling out the Moon's disk comes from sunlight reflecting off Earth's dayside up to the Moon, and then back to us. Literally, the Moon is bathed in earthshine. If it appears particularly bright, you can trace some lunar seas and bright craters through a small telescope.

Thanks to earthshine, it's easier to anticipate when the Moon will snuff out the light from some of the individual Pleiads. Slowly, the gray limb approaches a star, then swallows it in the wink of an eye. The best seats in the house are on the eastern seaboard. By the time it gets dark on the West Coast, the Moon has moved to the cluster's upper left, but the binocular view remains breathtaking. A number of the occultations may still be visible at sunset, so West Coast observers should set up early.

THE PLEIADES STAR CLUSTER plays a leading role in April's top event. The Moon glides in front of the cluster April 1. MICHAEL FIEST

The bright yellow, steady "star" high in the south is Saturn. Viewing the planet's small disk surrounded by rings is a sight beyond compare, even in the smallest telescope. Do you see a faint point of light just to the side? This dot is actually the big moon Titan. A 3-inch scope also reveals the moon Rhea, while a 6-inch pulls in Tethys, Dione, and the bizarre, two-faced Iapetus.

Use the circular sky chart in the foldout at right (after the poster) to locate Mars. The ruddy planet has faded considerably since its brilliant peak last autumn. It continues to drift eastward against a backdrop of winter constellations, two of which happen to contain stars of similar color. Both Aldebaran and Betelgeuse lie beneath Mars, and together the trio forms an almost perfect equilateral triangle around April 4. Unfortunately, Mars appears so small now that no details show up telescopically.

In contrast, Jupiter is huge, both at the eyepiece and in reality. The king of planets rises in the southeast in early evening. Despite the typical poor conditions in Earth's atmosphere so close to the horizon, Jupiter's cream-colored disk shows detail. Look for two parallel bands of purple brown, the primary belts of its cloud system. Will all four bright moons be visible? Have a look, then use the foldout section to identify each dot. Remember that a scope with a diagonal will flip the image left to right.

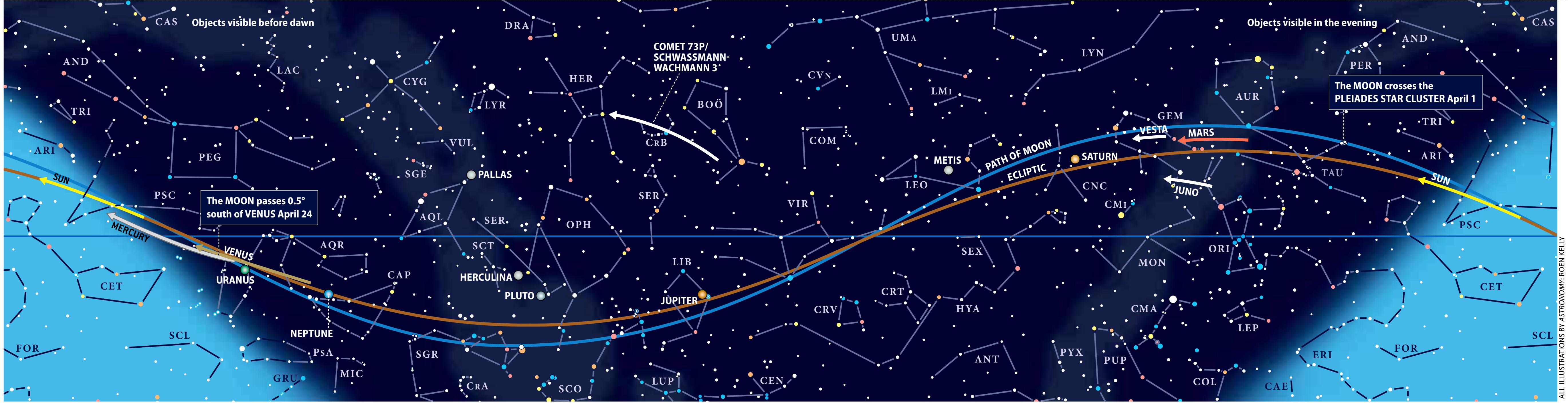
As our lunar companion makes its monthly journey around the sky, it passes above Mars on the 3rd, over Saturn on the 6th, and reaches Jupiter's area of sky on the 14th. During the following week, it plunges southward and its phase wanes, leaving the evening sky Moon-free for observing.

Avoiding the spray of light from both the Moon and any nearby city is important for appreciating the night sky's beauty and getting the most out of your eyes and telescope. Comet 73P/Schwassmann-Wachmann 3 should be sprouting a tail and growing bigger, but you won't see its gray light against city skyglow. If we're lucky, the comet will flare in brightness as it breaks apart — only time will tell.

Commonly called "shooting stars," meteors are swift streaks of light created when ancient comet debris burns up high in our atmosphere. During an annual meteor shower, like April's Lyrids, you might see a dozen or two per hour, but only from a dark site. This year, the Lyrids peak near dawn Saturday morning the 22nd. Gather in a group, bundle up against the crisp late-night air, and enjoy the stellar show.

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

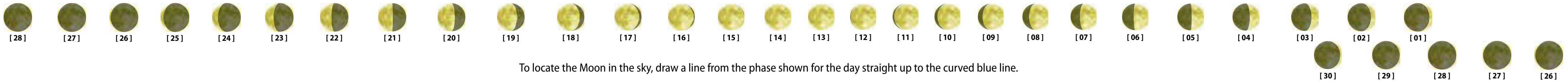


Objects visible before dawn
Objects visible in the evening
CAS
AND
LAC
CYG
DRA
HER
LYR
TRI
ARI
PEG
VUL
SGE
PALLAS
PSC
AQL
SER
OPH
SCT
AQR
CAP
HERCULINA
PLUTO
CET
MERCURY
VENUS
URANUS
NEPTUNE
SUN
SCL
FOR
PsA
GRU
MIC
SGR
CrA
SCO
LUP
LIB
JUPITER
CrB
BOÖ
COMET 73P/ SCHWASSMANN-WACHMANN 3
CVn
UMa
LMi
COM
VIR
LEO
METIS
PATH OF MOON
ECLIPTIC
SATURN
LYN
CNC
CMi
HYA
SEX
CRT
CRV
CEN
ANT
PYX
PUP
CMA
MON
GEM
VESTA
MARS
JUNO
AUR
ORI
LEP
COL
CAE
ERI
TAU
PER
CAS
AND
TRI
ARI
PSC
SUN
CET
FOR
SCL

The MOON passes 0.5° south of VENUS April 24

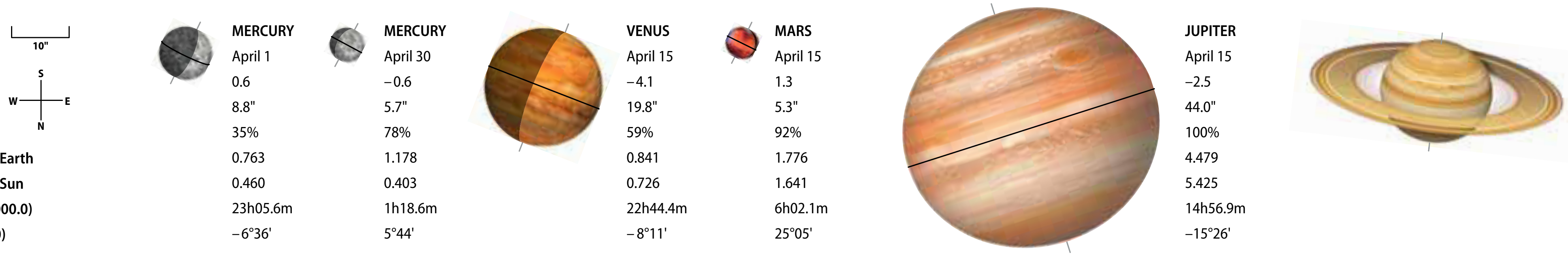
The MOON crosses the PLEIADES STAR CLUSTER April 1

ALL ILLUSTRATIONS BY ASTRONOMY: ROEN KELLY



[28]
[27]
[26]
[25]
[24]
[23]
[22]
[21]
[20]
[19]
[18]
[17]
[16]
[15]
[14]
[13]
[12]
[11]
[10]
[09]
[08]
[07]
[06]
[05]
[04]
[03]
[02]
[01]
[30]
[29]
[28]
[27]
[26]

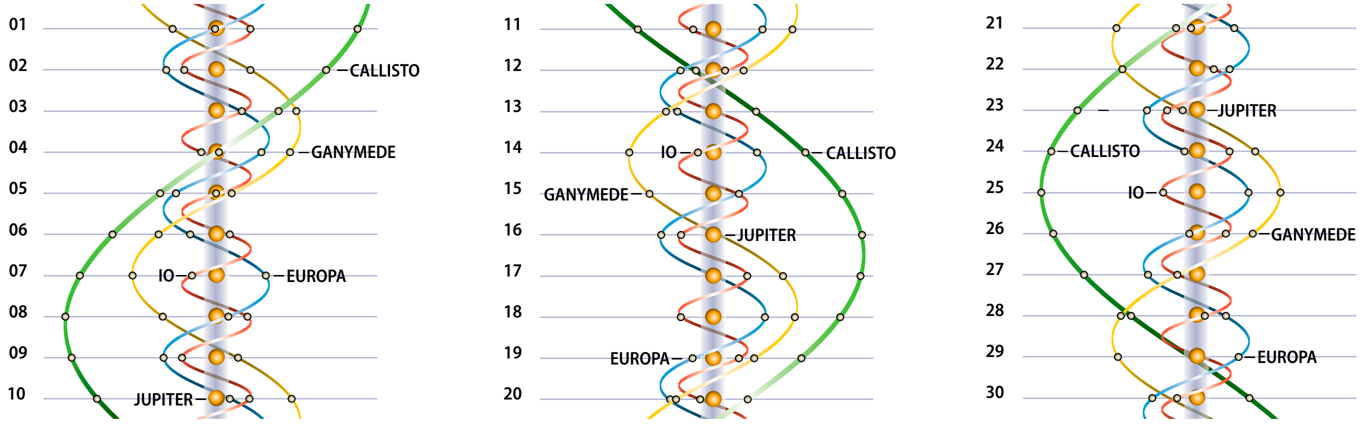
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.



PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	April 1	April 30	April 15	April 15	April 15	April 15	April 15	April 15	April 15
Magnitude	0.6	–0.6	–4.1	1.3	–2.5	0.2	5.9	7.9	13.9
Angular size	8.8"	5.7"	19.8"	5.3"	44.0"	18.7"	3.4"	2.2"	0.1"
Illumination	35%	78%	59%	92%	100%	100%	100%	100%	100%
Distance (AU) from Earth	0.763	1.178	0.841	1.776	4.479	8.905	20.815	30.459	30.617
Distance (AU) from Sun	0.460	0.403	0.726	1.641	5.425	9.125	20.079	30.056	31.099
Right ascension (2000.0)	23h05.6m	1h18.6m	22h44.4m	6h02.1m	14h56.9m	8h27.6m	22h58.6m	21h27.3m	17h46.0m
Declination (2000.0)	–6°36'	5°44'	–8°11'	25°05'	–15°26'	19°53'	–7°21'	–15°11'	–15°46'

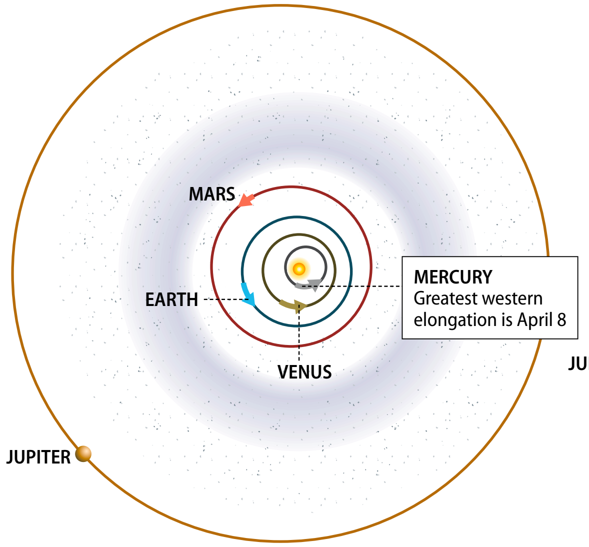
Jupiter's moons

Dots display positions of Galilean satellites at 4 A.M. EDT on date shown. South is at top to match the view through a telescope.



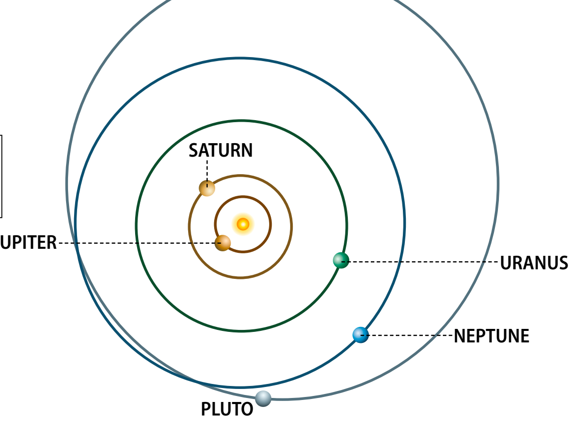
The planets in their orbits

Arrows and dots show planets' positions during the month.



MARS
EARTH
VENUS
JUPITER

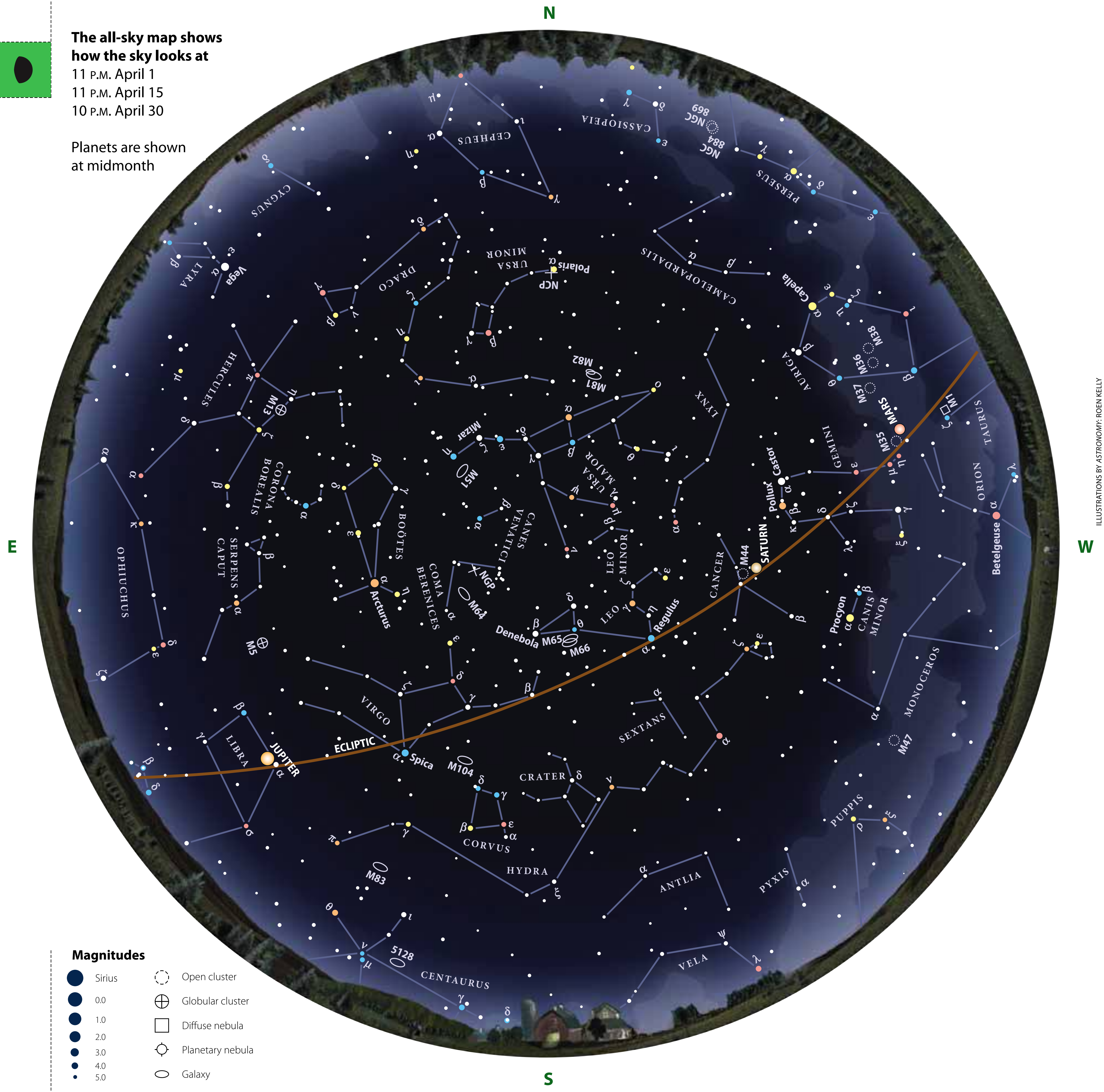
MERCURY
Greatest western elongation is April 8



JUPITER
SATURN
URANUS
NEPTUNE
PLUTO

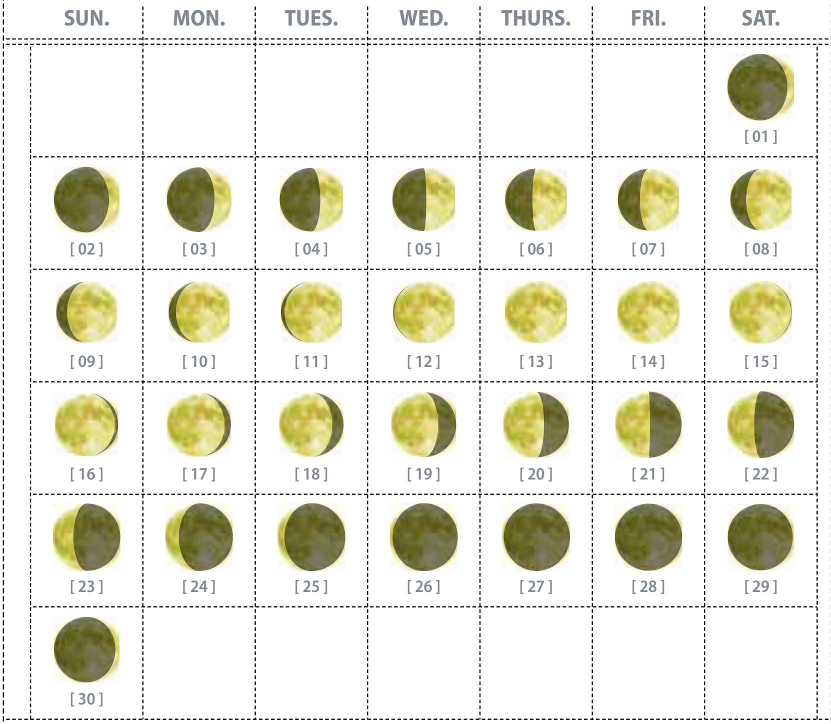
The all-sky map shows how the sky looks at
11 P.M. April 1
11 P.M. April 15
10 P.M. April 30

Planets are shown at midmonth


N
E
W
S
CASSIOPEIA
NGC 869
NGC 884
CEPHEUS
PERSEUS
CYGNUS
LYRA
Vega
DRACO
URSA MINOR
Polaris
NCP
CAMELOPARDALIS
Capella
AURIGA
M38
M36
M37
M82
M81
LYNX
HERCULES
M13
CORONA BOREALIS
Mizar
M51
URSA MAJOR
GEMINI
Castor
Pollux
MARS
M35
M1
TAURUS
ORION
Betelgeuse
SERPENS CAPUT
BOÖTES
CANES VENATICI
LEO MINOR
SATURN
M44
CANCER
OPHIUCHUS
Arcturus
COMA BERENICES
NGP
M64
LEO
Regulus
Procyon
CANIS MINOR
M5
Denebola
M65
M66
MONOCEROS
VIRGO
SEXTANS
ECLIPTIC
LIBRA
JUPITER
Spica
M104
CRATER
M47
PUPPIS
CORVUS
HYDRA
M83
ANTLIA
PYXIS
5128
CENTAURUS
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

april 06



SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
						[01]
[02]	[03]	[04]	[05]	[06]	[07]	[08]
[09]	[10]	[11]	[12]	[13]	[14]	[15]
[16]	[17]	[18]	[19]	[20]	[21]	[22]
[23]	[24]	[25]	[26]	[27]	[28]	[29]
[30]						

ILLUSTRATIONS BY ASTRONOMY: ROEN KELLY

03 The Moon passes 4° north of Mars, 4 P.M. EDT

05 Saturn is stationary, 8 A.M. EDT

First Quarter Moon occurs at 8:01 A.M. EDT

06 The Moon passes 4° north of Saturn, 7 P.M. EDT

08 Mercury is at greatest western elongation (28°), 3 P.M. EDT

09 The Moon is at apogee (251,997 miles from Earth), 9:17 A.M. EDT

13 Full Moon occurs at 12:40 P.M. EDT

The Moon passes 0.3° north of Spica, 1 P.M. EDT

15 The Moon passes 5° south of Jupiter, 11 A.M. EDT

17 The Moon passes 0.2° south of Antares, 5 A.M. EDT

18 Venus passes 0.3° north of Uranus, 8 A.M. EDT

20 Last Quarter Moon occurs at 11:28 P.M. EDT

22 The Moon passes 4° south of Neptune, 5 A.M. EDT

Lyrid meteor shower peaks

23 The Moon passes 1.2° south of Uranus, 10 P.M. EDT

24 The Moon passes 0.5° south of Venus, 10 A.M. EDT

25 The Moon is at perigee (226,013 miles from Earth), 6:33 A.M. EDT

26 The Moon passes 4° north of Mercury, 4 A.M. EDT

27 New Moon occurs at 3:44 P.M. EDT

ONLINE EXTRA For definitions of terms, visit www.astronomy.com/glossary.

THE DEEP SKY

Although Cancer the Crab is known for the wonderful Beehive star cluster, a pair of colorful variable stars there will give you months, if not years, of rewarding viewing.

Tracking variables

Once you get past luminaries like Aldebaran, Betelgeuse, and Antares, orange-red stars seem hard to come by. That's true only for visual observers like us, however — big telescopes with sensitive equipment detect faint red stars by the truckload because they're the most common type in the galaxy.

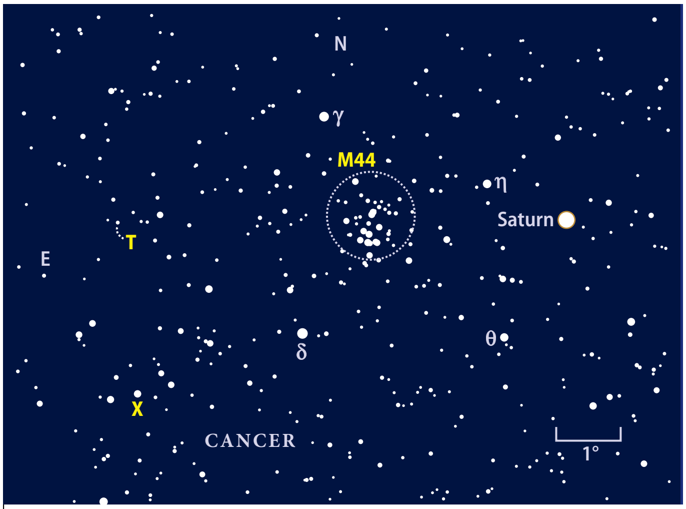
Without exception, bright orange-red stars vary in brightness. And they're bright only because they lie reasonably near. As variables go through their cycles, you can watch them shift from a brighter orange to a fainter red.

Two orange gems lurk near the Beehive star cluster (M44) just east of prominent Saturn this month. The Beehive is aptly named for its swarm of stars surrounding a dense knot of brighter ones. One of the closest clusters to Earth (600 light-years away), the Beehive typically shows up best through binoculars because of its extent.

One binocular field farther east (left for Northern Hemisphere observers), you can track down X and T Cancri. X Cnc takes about 165 days to fade from magnitude 5.9 to 7.3 and climb back again, which means you should be able to follow it with binoculars.

You'll need a telescope to observe T Cnc because its brightness ranges from magnitude 8.5 to 10.1. A 4-inch scope should do the trick from the suburbs. Revisit these stars every couple of weeks to see how much they have changed. T's rhythm is more subtle, thanks to its much longer period of about 485 days.

Visit the web site of the American Association of Variable Star Observers (aavso.org) to find a full-page chart showing X and T Cnc. You'll notice numbers next to some stars on the chart. These represent magnitudes, but their decimal points have been omitted to avoid confusion with stars. By comparing these constant stars with the target variable, astronomers can track a variable's behavior across the centuries.



ASTRONOMY: ROEN KELLY

X AND T CANCRI have distinct orange-red colors when viewed with optical aid. This is a sure sign they are variable stars.

NOAO/AURA/NSF

THE BEEHIVE STAR CLUSTER in central Cancer ranks among the nearest and brightest clusters in the sky. It makes a nice neighbor for Saturn this month.

Even if you're just starting to observe, you may have heard the phrase "use averted vision." This technique — looking a bit to the side — lets starlight fall on the more light-sensitive part of your retina. The funny thing here is that in order to see color, you need to use the retina's central cones, and that means looking straight at an object. Don't forget that people have different sensitivities to reds and oranges, so your color perception likely will differ from someone else's.

One of the nice things about variable-star viewing is you can observe many from a suburban backyard even in full moonlight. Deep-sky enthusiasts often leave their scopes packed up for 3 weeks a month waiting for a clear weekend around New Moon. For many of us, observing is a way to relax — why not do it more often? An hour's session in the evening just might be the ticket for winding down from a busy day.

You can find out more about this corner of the observing universe at the AAVSO web site or in David Levy's guidebook *Observing Variable Stars.*

Martin Ratcliffe *is the former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

THE PLANETS

Bright planets parade across the sky from early evening until dawn. They offer great views to observers using telescopes, binoculars, and even their unaided eyes.

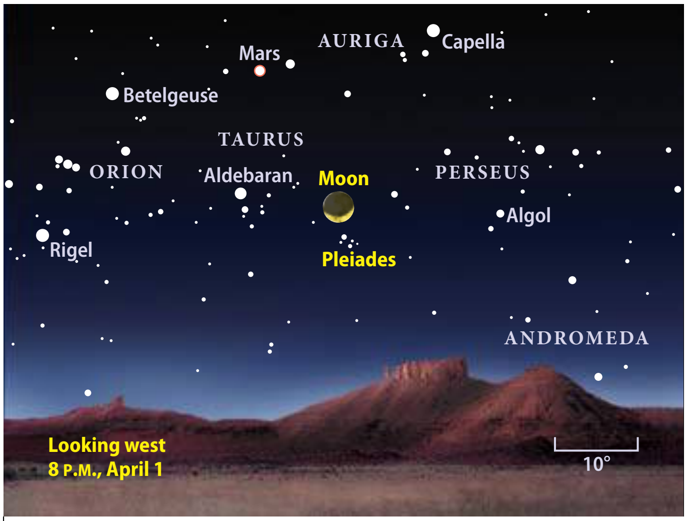
April's shorter, warmer nights make observing the planets a distinct pleasure after winter's cold. The ecliptic now slants at a steep angle relative to the western horizon after sunset, and the winter constellations are disappearing fast into the Sun's glow. Taurus the Bull carries with it Mars, which appears as a 1st-magnitude "star" near the equally bright Aldebaran.

Saturn looks spectacular early in the evening, and Jupiter takes over closer to midnight. With dawn coming a minute earlier each day, you'll need to be an early riser to catch the jewel-like brilliance of Venus low in the east-southeast. Invisible to the casual observer but nice targets for those using optical aid, Uranus and Neptune lurk near Venus.

On April 1, **Mars** stands between the two stars that mark the bull's horns in Taurus: Beta (β) and Zeta (ζ) Tauri. That same night, the waxing crescent Moon hangs below Mars and covers several stars in the Pleiades star cluster (M45). The Moon occults many cluster stars for those in the eastern half of the United States.

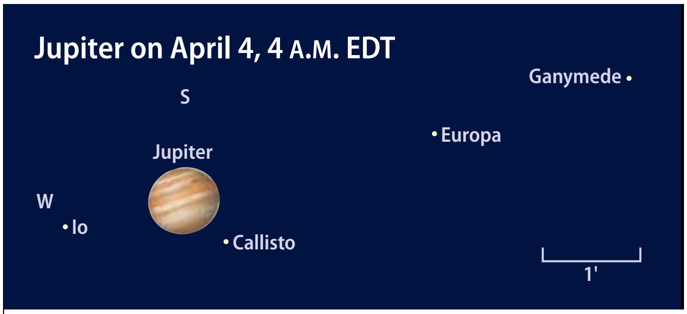
By the end of April, Mars has faded to magnitude 1.5. The dimming stems from the planet's increasing distance from Earth: In April's 30 days, Mars recedes from 153 million miles to 177 million miles. This vast gulf also means Mars appears tiny. It spans less than 6" all month — too small for most telescopes to show much detail.

Mars soon leaves Taurus and tracks eastward along the ecliptic. It moves to within 1° of the open cluster M35 April 17. Grab your binoculars to view the beautiful orange glow of Mars nestled against M35's outskirts. On April's last day, Mars stands a single Moon-width from the 3rd-magnitude star Epsilon (ε) Geminorum.



ASTRONOMY: TERRI FIELD

THE MOON SLIDES in front of the Pleiades star cluster April 1 and blocks many cluster stars from view.



ASTRONOMY: ROEN KELLY

JUPITER'S MOONS don't always line up. Occasionally, you will find Callisto above or below the planet.

Saturn remains visible all evening during April. On the 1st, it doesn't set until 5 A.M. local time, but it dips below the horizon 2 hours earlier by the 30th. Shining at magnitude 0.2, it's easily the brightest object in Cancer the Crab. Binoculars will show the Beehive star cluster (M44) just 3° east of Saturn. A waxing gibbous Moon joins the pair April 6, when it passes 4° north of the planet.

When viewed through a telescope, you should notice Saturn appears about 10-percent smaller than it did at opposition in late January. The planet's disk extends 19" at mid-month, while the ring system's long axis spans 42". As you view the rings, note the dark Cassini Division, which separates the outer A ring from the brighter B ring. You also should see the planet's shadow falling on the rings just east of the globe.

Any scope also reveals Saturn's largest moon, Titan. Glowing at magnitude 8.4, it can be spotted throughout its 16-day orbit of the planet. You'll find Titan due north of Saturn April 6 and 22 and due south April 14 and 30.

Saturn's other moons pose more of a challenge. Tethys, Dione, and Rhea all glow at 10th magnitude, but the last proves easiest to find because, of the three, it orbits farthest from the planet's glare. Expect to find it with a 3-inch scope. You'll need double that aperture to see Tethys and Dione clearly. Two-faced Iapetus lies east of Saturn this month, pointing its darker hemisphere in our direction. It glows around 12th magnitude, so you'll need an 8-inch scope to spot it.

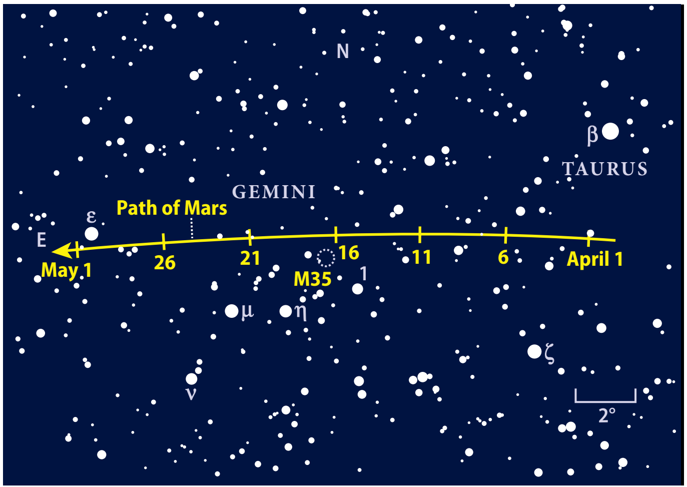
As it approaches opposition and best visibility in early May, **Jupiter** appears close to perfection during April. It gleams at magnitude –2.5, about 100 times brighter than Zubenelgenubi (Alpha [α] Librae), a bright star that lies a bit more than 1° from Jupiter this month. The planet rises before 11 P.M. local time April 1 and climbs highest during the early morning hours. By the end of April, Jupiter clears the horizon near sunset and appears highest in the south shortly after midnight. Greater altitude means better telescopic views because the planet's light travels through less of Earth's atmosphere. On April 15, the waning gibbous Moon passes 5° south of Jupiter.

Medium magnification — try 20x–30x per inch of aperture — gives the best view of atmospheric detail on the giant planet. The disk spans 44" in mid-April and easily shows its two dark equatorial belts. During the planet's 10-hour rotation period, different features parade across the disk. Tracking their changes each night is a good way to train your observing eye.

Jupiter's four Galilean moons glow bright enough to see through any telescope. The only time you won't see all of them is when one or more lie in front of or behind the planet's disk. Io, Europa, and Ganymede regularly experience these transits and occultations. Only Callisto, the most-distant bright moon, misses out because its orbit carries it above and below the planet as seen from Earth.

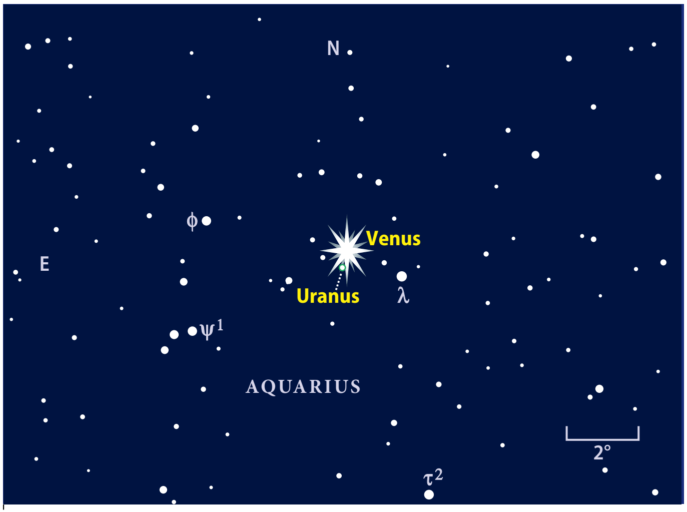
Neptune lies in Capricornus the Sea Goat 2° northeast of the 4th-magnitude star Iota (ι) Capricorni this month. The distant world lies 2.8 billion miles from Earth and glows dimly at magnitude 7.9. You'll need binoculars to see Neptune and a telescope to resolve its 2.2"-diameter disk. It will reach opposition in mid-August.

Neptune's gas-giant cousin, **Uranus**, resides one constellation farther east, in Aquarius the Water-bearer. Use the 4th-magnitude star Lambda (λ) Aquarii as a guide — the planet lies 1° east of Lambda April 1. During April, Uranus wanders approximately 1° to the northeast, arriving in close proximity to 6th-magnitude 81 Aquarii. Glowing at magnitude 5.9, Uranus is easy to spot with binoculars. A telescope reveals a distinctly blue-green disk that measures 3.4" across.



ASTRONOMY: ROEN KELLY

THE RED PLANET passes just north of the bright open cluster M35 in mid-April, when they make a fine sight in low-power scopes.



ASTRONOMY: ROEN KELLY

VENUS MEETS URANUS in the predawn sky April 18. Use binoculars or a telescope to see this event.

Venus rises in the east-southeast around 5 A.M. local daylight time. Gleaming at magnitude –4.1, it easily outshines every other point of light in the sky. The view through a telescope on the 1st reveals a half-illuminated planet, which looks like a miniature version of a Last Quarter Moon. As you follow Venus during the month, you'll see its phase wax to nearly two-thirds lit.

Venus' rapid orbital motion carries it away from us this month. The increasing distance causes the planet's apparent size to shrink noticeably, from 23" to 17" across. On April 18, Uranus lies just 18' south of Venus. The pair stands 10° above the eastern horizon at about 5:30 A.M. local daylight time. The Moon lies 2° to the lower right of Venus April 24.

The innermost planet makes a mediocre morning appearance during April. On the 1st, **Mercury** shines at magnitude 0.6 and is difficult to see in the brightening dawn sky. When it reaches greatest western elongation (28°) on the 8th, it shines at magnitude 0.3. Mercury continues to brighten during April, climbing to magnitude –0.6 by month's end, but it also sinks deeper into the twilight glow.

METEORS AND MOONS

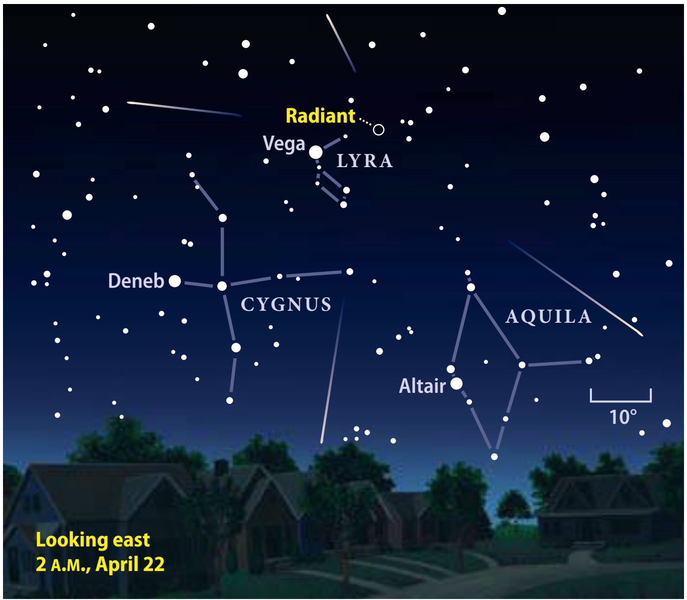
The meteor doldrums of winter come to a close with the return of the annual Lyrids. Two large and prominent craters highlight an intriguing region of the Moon's southern highlands.

Meteors from the Harp

Following the dearth of meteor showers during February and March, April opens the warm-weather meteor season with the moderately active Lyrids. The shower peaks April 22, with reduced activity visible for a few days before and after. The waning crescent Moon stays out of the shower's way this year, so dark skies will rule if you observe from the country.

The Lyrids appear best after midnight, once the radiant rises more than 40° above the horizon. It's easy to trace the path of a meteor backward to see if it intersects the compact constellation Lyra the Harp. This will tell you whether the meteor you observed is a shower member or just a sporadic.

Lyrid meteors hit Earth's atmosphere at 30 miles per second — a modest speed by meteor standards.



ASTRONOMY: ROEN KELLY

LYRID METEORS will pepper the sky before dawn April 22. You can expect to see up to 20 meteors per hour at the peak.

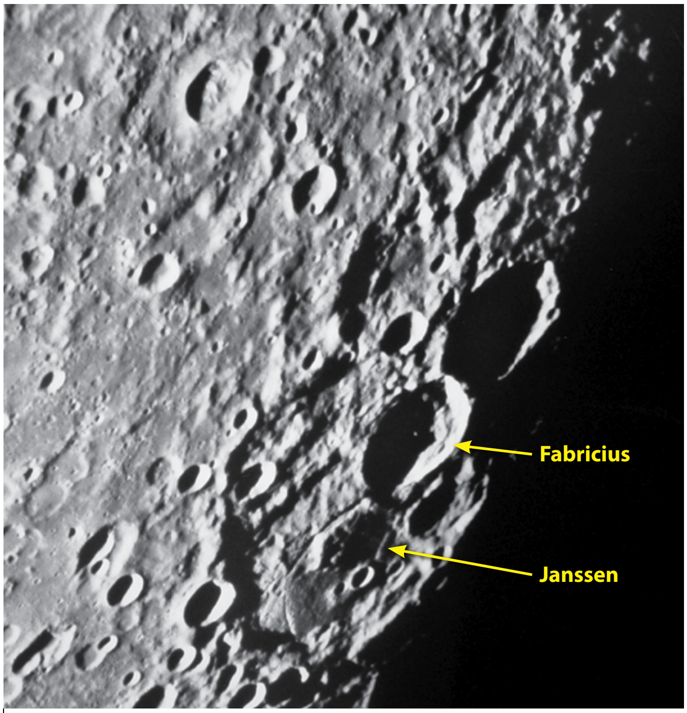
Janssen and Fabricius

As the Sun rises over the Moon's southeastern quadrant in the days following New Moon, it illuminates the heavily cratered southern highlands. One of the biggest and most ancient craters here is Janssen, a 118-mile-wide gouge. Repeated impacts long after the crater's formation have pummeled its rough outline. When the first rays of sunlight catch this complex crater April 2, they also illuminate a well-formed crater on its northeastern wall called Fabricius. The latter spans 48 miles and provides a guide to discovering the rest of Janssen.

By April 3, sunlight illuminates the whole region. You'll see Janssen's poorly defined rim and the numerous craters that dot its floor. A long, curved rille extends from Fabricius' southwestern wall to the southwest and then turns south. It crosses Janssen's floor before ending in a smooth region at the southern edge of the complex.

This rille, the only one in the region, skirts an elevated area at the crater's center. The rise may be the remains of a mountain peak formed during the impact that created Janssen early in the Moon's history. However, the raised region's steep southwestern side, noticeable on the side farthest from Fabricius, suggests another possible origin — the impact that produced Fabricius itself.

The floor on Janssen's northern side appears jumbled. The central mountain, the rille, and this jumbled terrain may all be linked to the impact that created Fabricius, but much remains a mystery in this region. Janssen itself becomes hard to distinguish from its cratered surroundings under high illumination. Good views return when the Sun sets over the region April 17.



FROM CONSOLIDATED LUNAR ATLAS (LPL/UA)

JANSSEN AND FABRICIUS appear conspicuous when the Sun rises or sets over this part of the lunar highlands but show little detail when the Sun lies directly overhead.

COMETS AND ASTEROIDS

Spring's brightest comet — the tongue-twisting 73P/Schwassmann-Wachmann 3 — should brighten significantly and show up nicely in small telescopes. If not, you can rely on rocky Vesta.

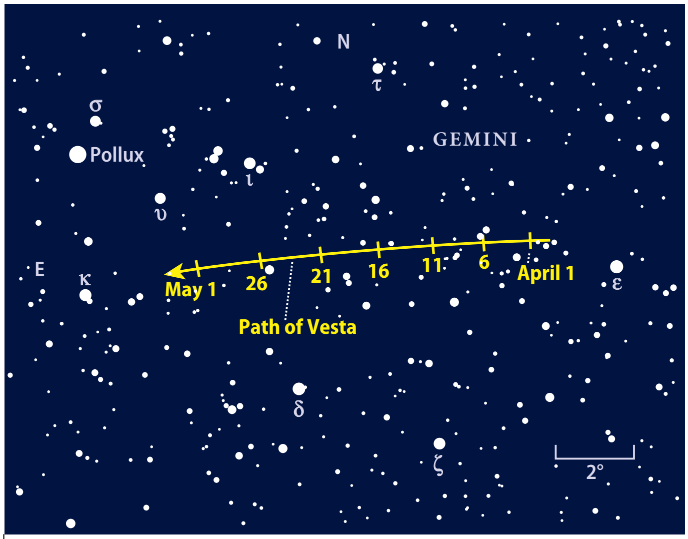
Spectacle or dud?

Comet scientists and amateur astronomers alike eagerly await the return of Comet 73P/Schwassmann-Wachmann 3. It could flare up to 2nd magnitude at its peak in May. That would make it appear as a bright blob under rural skies and a great binocular object from suburbia. On the other hand, we may see a faint fuzzball, or something in between.

Why are astronomers this uncertain? In 1995, observers saw the comet break into four main pieces. On its last return in 2001, three were seen. As 2006 began, only component C had been recovered. When comets break apart, fresh ice gets exposed to sunlight, which often causes the brightness to jump. Just look at what happened last July when the Deep Impact probe smashed into Comet 9P/Tempel 1, exposing fresh material and causing the comet to flare up a bit. But, we've also seen these dirty snowballs simply dissolve into diffuse clouds, detectable only with CCD cameras.

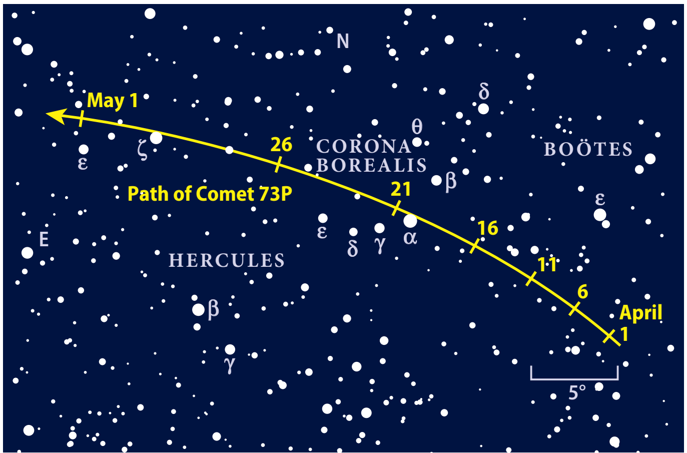
Comet experts think Schwassmann-Wachmann 3 could brighten to around 7th magnitude by the end of April, which would bring it within range of small scopes under a moonless night away from city lights. But, of course, we're all hoping for it to be visible to the unaided eye, a possibility that grows stronger as the comet approaches Earth in May.

During the last week of April, Comet 73P travels eastward from Corona Borealis into Hercules. This region remains visible all night from most of the Northern Hemisphere, but the best views will come when it climbs highest after midnight. The comet should have a bright core surrounded by a large but faint halo. This halo will disappear under light-polluted skies, however, so try to find as dark an observing site as you can.



ASTRONOMY: ROEN KELLY

ASTEROID VESTA recedes from Epsilon (ε) Gem, which still makes a good guide to the 8th-magnitude minor planet this month.



ASTRONOMY: ROEN KELLY

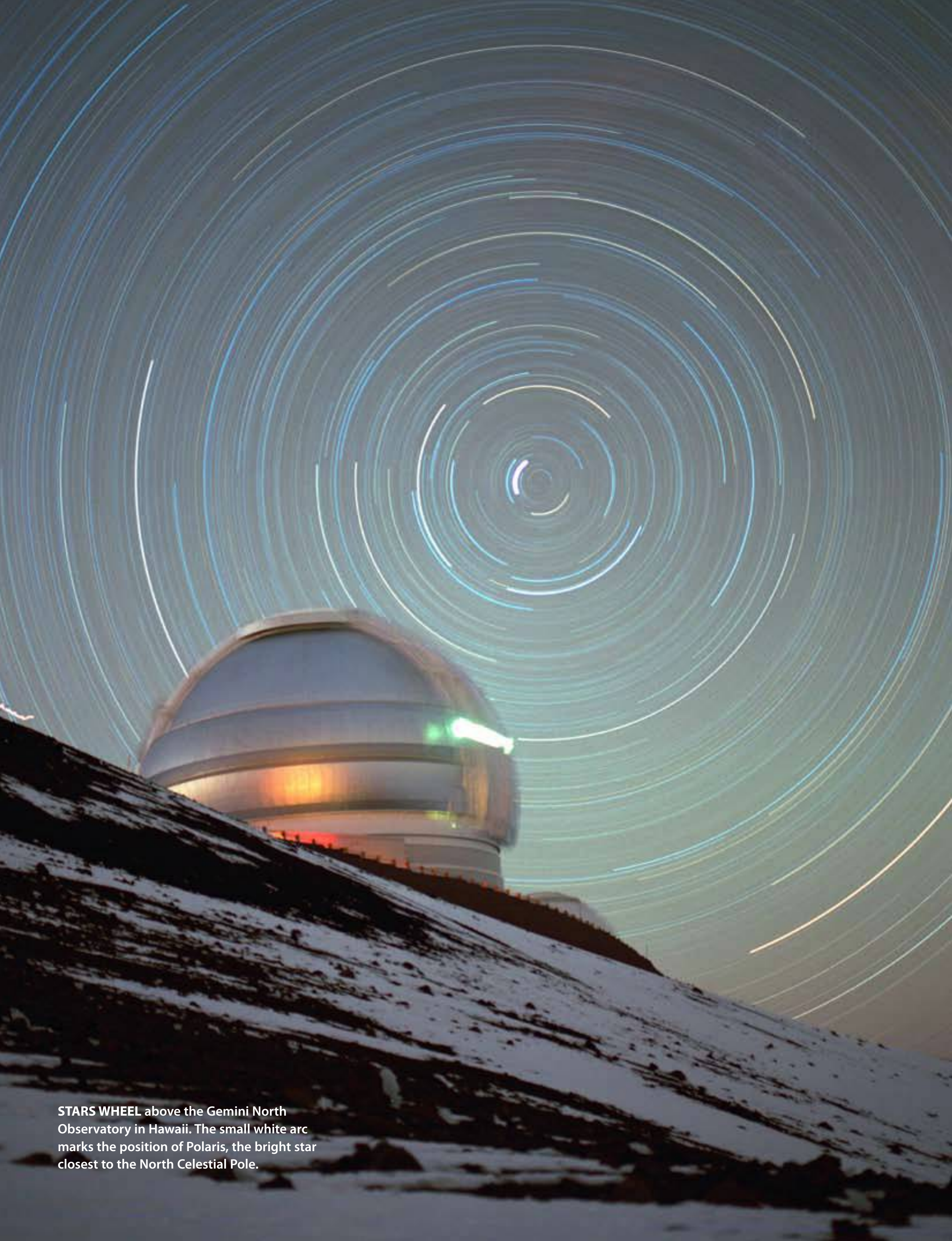
A BRIGHT VISITOR could light up the spring sky, but no one knows how good Comet 73P/Schwassmann-Wachmann 3 will become. Track it as it makes its way from Boötes to Hercules.

Reliable Vesta

In contrast to the unpredictable behavior of their cometary cousins, asteroids hold few surprises. Astronomers can predict their brightnesses to within a tenth of a magnitude. Their rough, cratered surfaces stay pretty much the same, as they reflect roughly 15 percent of the sunlight that strikes them.

Robotic space missions and radar studies from Earth show the rocks that rule the space between Mars and Jupiter have a wide range of shapes mimicked well by potatoes. Some are binaries or contact doubles, but the bigger ones like Vesta are nearly round. As these huge boulders rotate, their brightnesses change and enable astronomers to figure out how long it takes them to turn. In Vesta's case, the day passes quickly, in just 5.34 hours.

Vesta fades slowly during April, dimming from magnitude 7.8 to 8.1. It treks through the rich star fields of Gemini the Twins — roughly between 3rd-magnitude Epsilon (ε) Geminorum and 1st-magnitude Pollux — so it's well camouflaged. You may need to track it down the old-fashioned way: Use the chart above to home in on the search area, then make a quick sketch of the brighter objects. Come back a night or two later to see which one moved. It will take Vesta about 4 nights to cross a low-power field of view. ■



STARS WHEEL above the Gemini North Observatory in Hawaii. The small white arc marks the position of Polaris, the bright star closest to the North Celestial Pole.

SPECIAL STARS ISSUE

All about the NORTH STAR

Polaris, navigators' guiding light, is evolving right before astronomers' eyes. /// BY KEN CROSWELL

Most of us find comfort in the Sun's stability. But this stability means astronomers can't observe its changes to study how stars evolve over time. Fortunately, one bright star has been changing right before their eyes. Ironically, it's an object long revered as a symbol of stability and fidelity, one that, for ages, has aided mariners and explorers: Polaris, the North Star. Controversial new research suggests Polaris is brightening. It's now more than 15-percent brighter than it was 100 years ago — and more than twice as bright as it was 2,000 years ago.

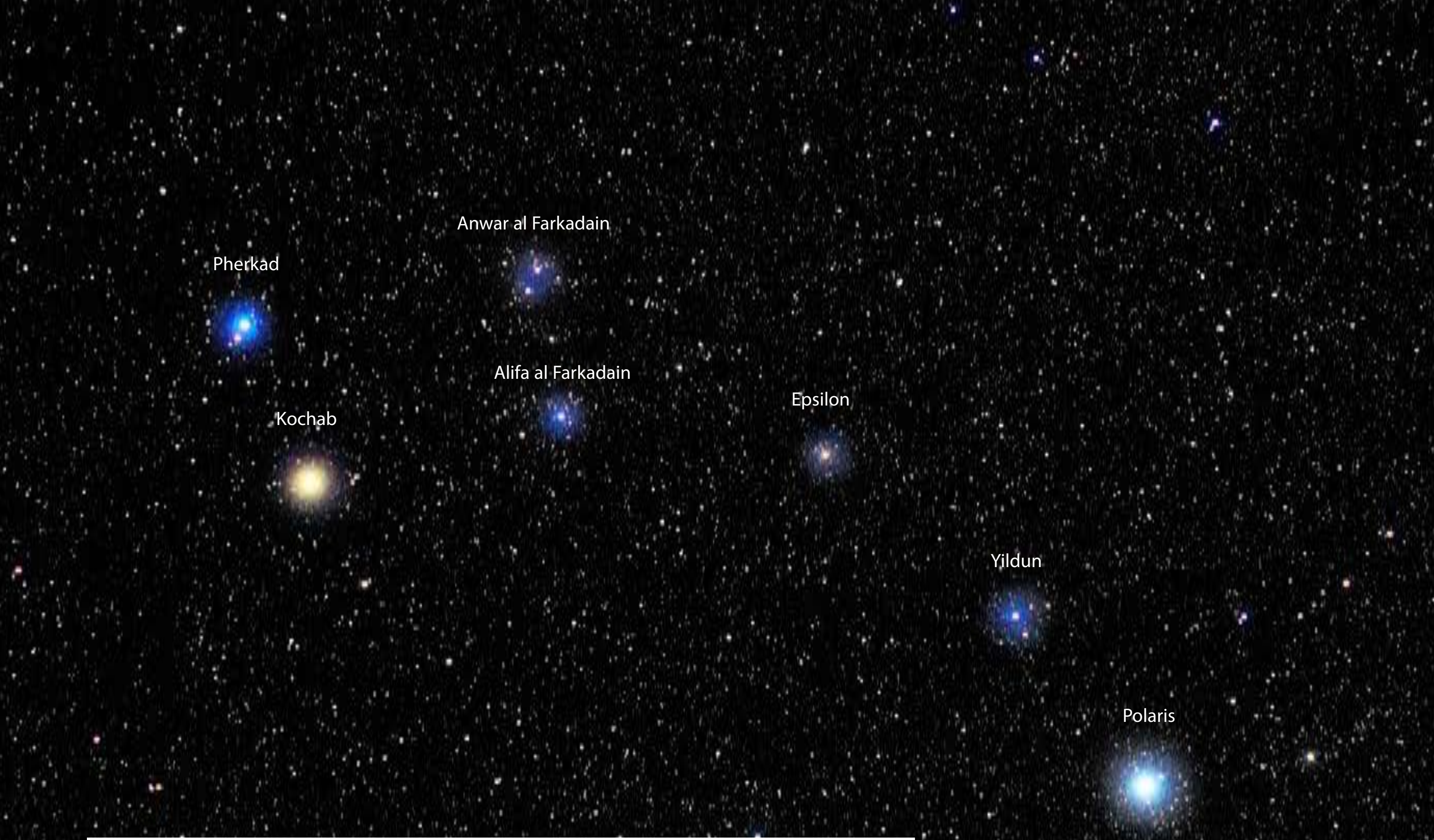
Ken Croswell, *a Harvard-trained astronomer, is a frequent contributor to* Astronomy *and author of several books, including* Magnificent Universe *(Simon & Schuster, 1999).*

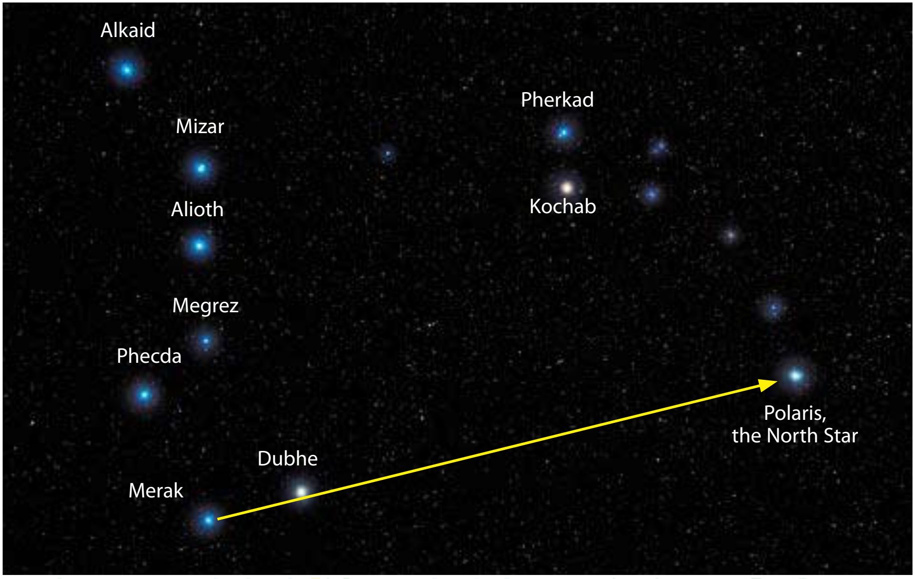
The remarkable North Star

Polaris now lies less than 1° from the North Celestial Pole, an extension of Earth's spin axis and the point around which the northern sky appears to rotate. But the North Star wasn't always located so conveniently.

Earth's rotational axis wobbles, causing it to point in different directions. Normally, the axis points at nothing in particular; but for the past several centuries, it's been aimed toward Polaris. In fact, this wobble is bringing Polaris ever closer to the North

GEMINI OBSERVATORY





▲ **THE NORTH STAR** **outshines all others in the constellation Ursa Minor the Little Bear. Earth's spin axis now points less than 1° from Polaris, which is why you never see the star rise or set.**

◀ **STARS IN THE BOWL** **of the Big Dipper (left), an asterism formed by Ursa Major's brightest stars, guide observers to Polaris. The "pointer stars" are Merak and Dubhe.**

BILL AND SALLY FLETCHER

Celestial Pole, and it will continue to do so until the year 2102. Rarely has Earth been blessed with such a good North Star.

Many nonastronomers mistakenly think the North Star is the brightest in the sky. It does, however, rank a respectable 2nd magnitude, which makes it bright enough to see even from light-polluted locations.

While much of its fame rests on its utility for finding true north, Polaris also reveals an observer's latitude on Earth. If Polaris stands 30° above the horizon, you're at 30° north latitude. If it's 60° high, you're at 60° north. And if Polaris appears directly overhead, you're at Earth's North Pole.

A star with a pulse

The North Star's remarkable traits don't end there. Polaris belongs to a class of stars whose story began in September 1784, when English astronomer Edward Pigott discovered the fluctuating light of a yellow star named Eta Aquilae. A month later, his friend John Goodricke found similar variations in another yellow star, Delta Cephei, and the stars came to be called Cepheids.

Cepheids are yellow supergiants of spectral class F or G that pulsate like a human heart — they expand and contract, brighten and fade. Cepheids are such luminous stars that astronomers can see them in galaxies beyond our own.

A pulsating supergiant is remarkable enough. But in 1907, Harvard astronomer Henrietta Leavitt uncovered the most astonishing Cepheid property: The longer a Cepheid takes to pulsate, the more light it emits into space. Thus, Cepheids make excellent yardsticks for measuring distances to other galaxies. Simply measure a Cepheid's period of pulsation — which is easy to do — and you know its true brightness. Compare the true brightness with the Cepheid's apparent brightness, and you learn something much more precious: how far the star is from Earth.

In the 1920s, Edwin Hubble used Cepheids in so-called spiral nebulae to show these objects are really galaxies beyond our own. Cepheids also helped Hubble discover the universe's expansion. Today, using the space telescope named for Hubble, astronomers observe Cepheids to measure the universe's expansion rate.

Polaris is a Cepheid, too. In fact, it's the closest and brightest member of this important stellar class. But unlike most stars of this type, Polaris' light barely fluctuates, so astronomers didn't discover its Cepheid nature until the 1910s.

Most Cepheids pulsate with the precision of a Swiss watch. Eta Aquilae, the first Cepheid discovered, completes one pulsation cycle every 7 days, 4 hours, 14 minutes, and 34 seconds — exactly.

Not Polaris. Its 3.97-day period gains 3 or 4 seconds a year. Furthermore, in 1983, Armando Arellano Ferro, a Mexican astronomer working at the University of Toronto, reported the star's already feeble flickerings were fading further. During the early 1900s, its light varied by 0.10 to 0.15 magnitude. In the 1980s, however, it fluctuated by just 0.05 magnitude.

The rise and fall of Polaris' light continued to decline. A team led by Canadian astronomer Don Fernie predicted that, in 1994, the star would be as constant as, well, the North Star. Polaris seemed destined to make history as the first ex-Cepheid ever seen.

The beat goes on

That didn't happen. Not only did Polaris keep pulsating — recently its pulsations have strengthened. After fluctuating by a mere 0.02 magnitude in the early 1990s, the light now varies by 0.03 to 0.05 magnitude.

What's going on? In 1997, the European satellite Hipparcos provided fresh insight. It measured the star's parallax and revealed Polaris is 430 light-years from Earth. For Polaris to be seen as a 2nd-magnitude star at this distance, it must emit 2,400 times more light than the Sun. Put another way: In an hour, Polaris casts more light into space than the Sun does in 3 months.

In fact, it's too bright. Polaris is too luminous to be a normal Cepheid with a 3.97-day period. A Cepheid as big and bright as Polaris should pulsate more slowly, just as a large musical instrument like a tuba produces a lower pitch than a small one like a trumpet. Polaris' period should be around 6 days. This longer period is called the star's fundamental pulsation mode. But just as musical instruments have overtones, or harmonics, so do Cepheids. Polaris seems to be pulsating in its first overtone.

That explains a lot, astronomers say. "Overtone pulsators tend to have periods which change unusually rapidly — for

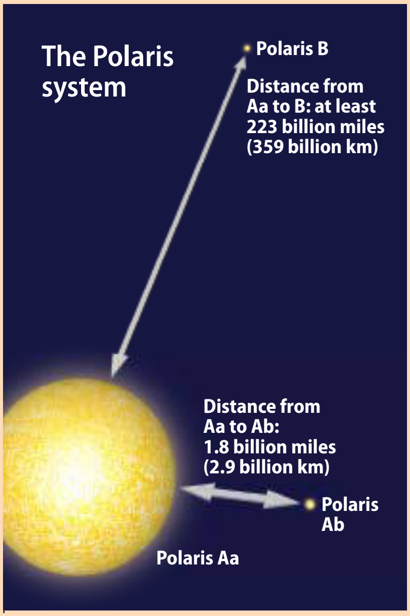
BILL AND SALLY FLETCHER

POLARIS AND FRIENDS

Polaris is actually a triple star. The brightest member of the system is the Cepheid, an F7 supergiant about 5 times more massive than the Sun. Both stars have similar surface temperatures — about 6,000 K — so their color is similar, too. Polaris pulsates every 3.97 days.

Polaris B, an F-type main sequence star, orbits 18" away and shines at 9th magnitude — easy to see in a small telescope. If both Polaris and this companion are exactly 430 light-years from Earth, then they're separated by 2,400 astronomical units, or about 60 times Pluto's distance from the Sun. (One astronomical unit, or AU, is Earth's average distance from the Sun, about 93 million miles [150 million kilometers].) Polaris B must take tens of thousands of years to complete an orbit.

The system's third member orbits Polaris A every 29.6 years, tugging on it and altering its velocity with this same period. But this star went unseen until 2005, when the Hubble Space Telescope finally spotted it. It's an F main sequence star. On average, this companion lies as far from the supergiant as Uranus lies from the Sun. — *K. C.*


The Polaris system
Polaris B
Distance from Aa to B: at least 223 billion miles (359 billion km)
Distance from Aa to Ab: 1.8 billion miles (2.9 billion km)
Polaris Ab
Polaris Aa

ASTRONOMY: ROEN KELLY

TWO STELLAR companions orbit the North Star. The closer Ab component orbits about as far from its primary as Uranus does our Sun. Using the Hubble Space Telescope, astronomers recently imaged this component for the first time.

ANACHRONISM OR IRONY?

I am constant as the northern star,
Of whose true-fix'd and resting quality
There is no fellow in the firmament.
The skies are painted with unnumb'red sparks,
They are all fire, and every one doth shine;
But there's but one in all doth hold his place.

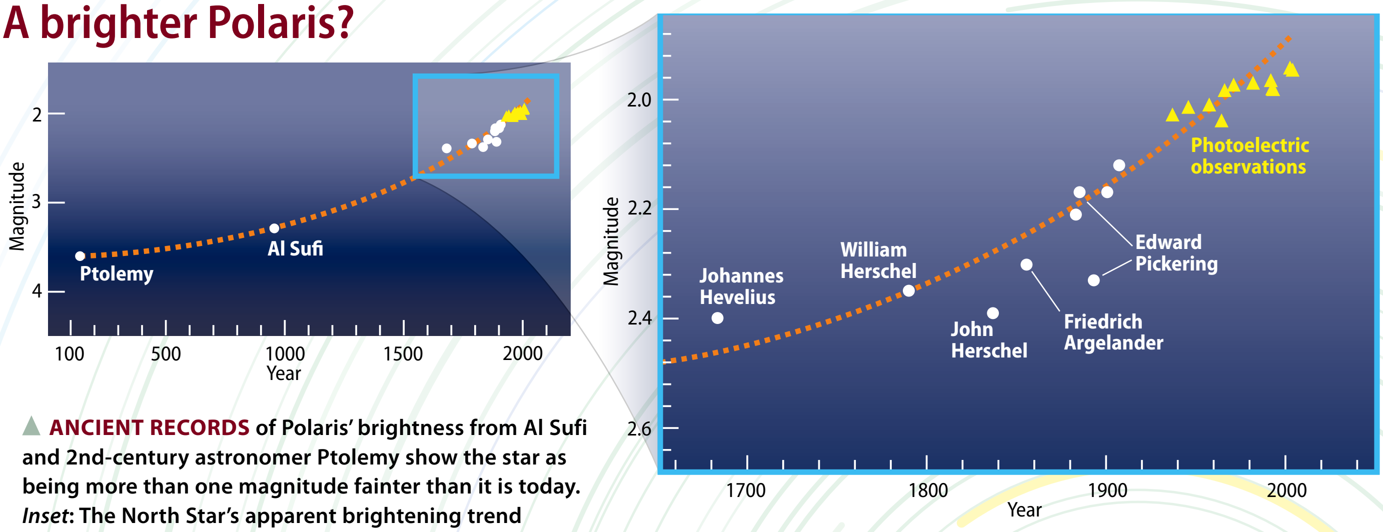
In 1599, when William Shakespeare put these words into the mouth of Julius Caesar, Polaris was about 2° farther from the North Celestial Pole than it is today. The trouble is, the North Star lay even farther away in Caesar's time.

Shakespeare's plays include anachronisms, and his "constant" North Star may be an example of one. But the playwright may have intended these words as ironic. Conspiring senators murder Caesar just a few lines after he utters them. — *K. C.*

IN *JULIUS CAESAR*, William Shakespeare has Rome's famous dictator compare himself to Polaris.

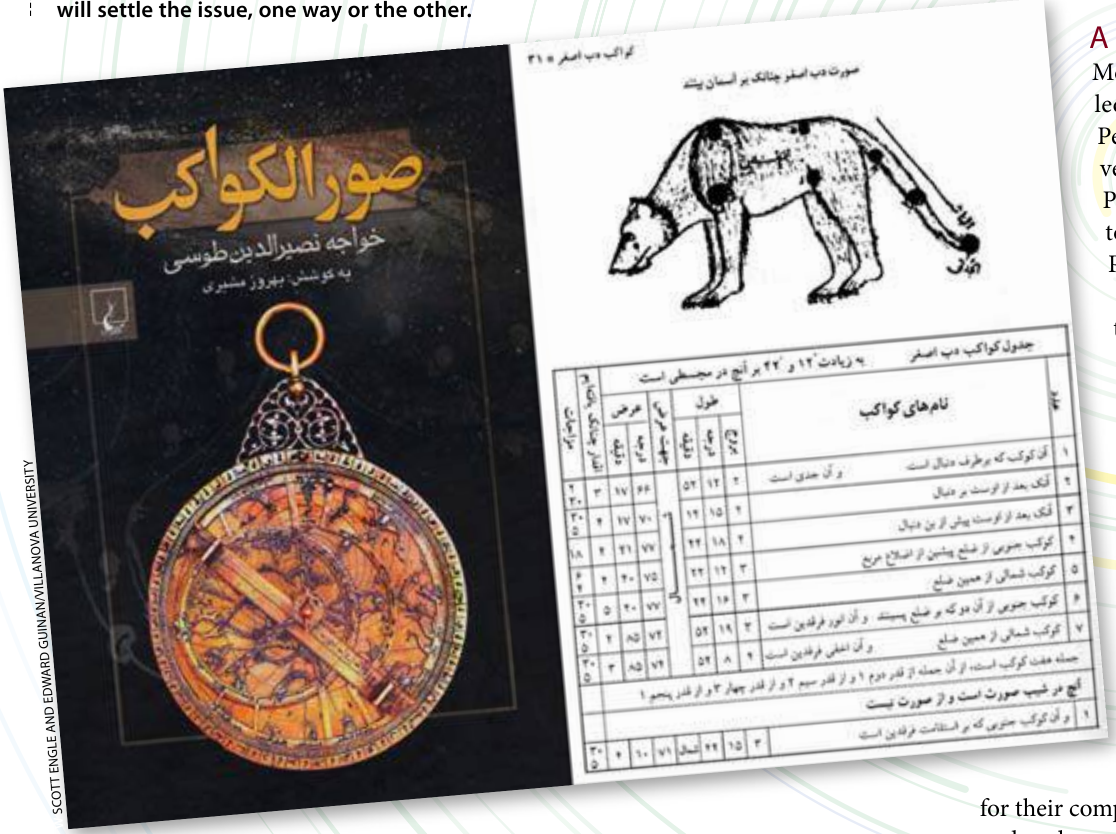
FROM *HISTORY OF THE WORLD*, 1902

A brighter Polaris?



ASTRONOMY: ROEN KELLY, AFTER S. ENGLE AND E. GUINAN

▲ **ANCIENT RECORDS of Polaris' brightness from Al Sufi and 2nd-century astronomer Ptolemy show the star as being more than one magnitude fainter than it is today. *Inset*: The North Star's apparent brightening trend continues into modern times, but not all astronomers agree it's real. Measurements made in the next few years will settle the issue, one way or the other.**



SCOTT ENGLE AND EDWARD GUINAN/VILLANOVA UNIVERSITY

EIGHTH CENTURY Persian astronomer Al Sufi recorded Polaris' position and brightness in his *Book of the Fixed Stars*.

reasons that we don't understand," notes Nancy Evans of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts. Many Cepheids pulsate in their first overtone, and this pattern is especially common among short-period Cepheids like Polaris. (It takes months for the largest, brightest Cepheids to complete a single pulsation.) In addition, overtone pulsators tend to show modest light fluctuations, just as Polaris does.

A normal Cepheid, such as Eta Aquilae, brightens fast and fades slowly, whereas Polaris takes just as long to brighten as it does to fade. In 2004, Evans and her colleagues used NASA's Wide-Field Infrared Explorer (WIRE) satellite to measure the star's light to the incredible precision of 1⁄10,000 of a magnitude. Their analysis confirmed that the rise and fall of the North Star's light shares traits of stars known to be overtone pulsators.

A bright future?

Meanwhile, in 2002, a team led by Edward Guinan of Pennsylvania's Villanova University began observing Polaris — and tracing its history. The group's conclusion: Polaris is getting brighter.

"That was the most startling thing," says Guinan. "It looks as though over the past 50 years — from 1955 to the present — its average magnitude changed from about 2.02 to 1.97." He decided to go back and look at even earlier data. "This gets you into trouble rather fast, because you have to worry about nonstandard systems for measuring brightness. So you have to recalibrate everybody's observations, putting in modern values for their comparison stars." When Guinan and undergraduate Scott Engle did so, they found Polaris was even fainter in the 1800s — between magnitudes 2.2 and 2.3.

"We decided to do the full thing," says Guinan. "We went back and we looked in Ptolemy's catalog — and Polaris is listed as 3rd magnitude. So that was curious, but you know, he did make mistakes."

While Claudius Ptolemy, who lived nearly 2,000 years ago, didn't have the precision instruments of modern astronomers, it's pretty easy to see the difference between 2nd- and 3rd-magnitude stars. Even someone who's never seen the Big Dipper's seven stars before can pick out the one shining at 3rd magnitude; the rest are 2nd magnitude.

A book Guinan found during a visit to Iran convinced him Polaris had been fainter in the past. "I gave a little talk on different types of variable stars, and I threw in Polaris. An astronomer there, Yousef Sobouti, mentioned a catalog by Al Sufi [903–986], a Persian astronomer.… His measures of the stars in the Little Dipper were much better than Ptolemy's measurements — they were nearer to the modern values — and Polaris was listed as 3rd magnitude again."

Guinan doesn't know what's causing Polaris to change. "The changes in period, the changes in light are much faster than you predict by standard stellar-evolution theory," he says. "But my guess is that it's undergoing some kind of internal change."

Not everyone agrees Polaris is brightening. David Turner, a Canadian astronomer at Saint Mary's University in Halifax, isn't convinced. He says German astronomer Julius Schmidt measured the star at its current brightness in the 1850s.

Furthermore, Turner thinks the Hipparcos distance — 430 light-years — is wrong. Based on the apparent and absolute brightnesses of stars near Polaris, which form a small group to which the North Star may belong, Turner thinks Polaris is only 300 light-years from Earth. As Turner notes, Hipparcos has flubbed other distances — most famously, to the Pleiades star cluster. If Polaris is only 300 light-years away, it must be less luminous, so much so that Polaris would be pulsating in its fundamental, rather than its overtone, mode.

Turner thinks Polaris has just evolved from being a blue main sequence star, like Regulus in Leo, into a yellow supergiant going through a pulsation phase on its way to becoming a red supergiant. Such stars are rarer than other Cepheids because they evolve faster, but Turner says this explains recent changes in the star's period and amplitude. In his view, Polaris' period is lengthening because the star is getting bigger and redder — and will someday stop pulsating altogether. So far, though, no one has been able to detect a steady color or temperature change, so no one knows whether Polaris is getting redder or bluer.

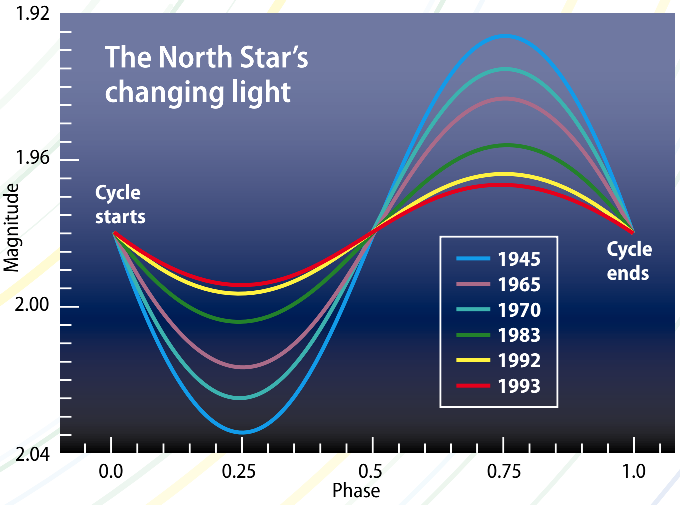
Fortunately, there are easy ways to resolve many of the disputes. Using the Hubble Space Telescope's (HST) Fine Guidance Sensors, Howard Bond of the Space Telescope Science Institute in Baltimore and his colleagues plan to measure a precise parallax for Polaris. This will either confirm or refute the Hipparcos distance. An accurate HST distance will determine whether Polaris is a fundamental-mode pulsator, as Turner believes, or an overtone pulsator, as Evans and Guinan think. And if the star is really brightening, as Guinan and Engle maintain, it will take just a few more years of observations to show it.

There's one thing everyone agrees on. Polaris is young — about 100 million years old — so any planets it may harbor probably haven't yet developed life. As Guinan notes, the star moves through space in the same direction as the Pleiades, a cluster with stars of similar age, so Polaris probably formed at the same time as the cluster. And if the Hipparcos distance to Polaris turns out to be right, the North Star is nearly as far as the Pleiades cluster, about 435 light-years away.

Says Turner: "It's a star that will prove interesting to follow for years to come — whatever it happens to do." If, against all odds, the star does have planets with intelligent life, Polarians have no idea how special their star is to us — just as we have no idea whether the Sun is some other planet's North Star, guiding sailors across alien seas, and perhaps even inspiring extraterrestrial playwrights to wax poetic.

/// TWO STARS COMPARED

	Polaris	Sun
Constellation	Ursa Minor	—
Distance (light-years)	430	—
Apparent magnitude	1.97	–26.74
Absolute magnitude	–3.6	4.83
Relative brightness	2,400	1
Spectral type	F7	G2
Color	Yellow-white	Yellow
Surface temperature	6,000 K	5,770 K
Relative mass	4.3 ± 1.1	1
Relative radius	46	1
Age (years)	About 100 million	4.6 billion
Relative iron abundance	1	1
Relative carbon abundance	0.4	1
Relative nitrogen abundance	2.5	1



MEASUREMENTS OF POLARIS' cyclic brightness changes showed they were decreasing with time. Astronomers predicted the star would stop fluctuating entirely by the mid-1990s. Polaris has since strengthened its pulsations.

ASTRONOMY: ROEN KELLY, AFTER S. ENGLE AND E. GUINAN

ONLINE EXTRA Polaris hasn't been Earth's only North Star. Find out more at www.astronomy.com/toc.

DEEP-SKY OBSERVING

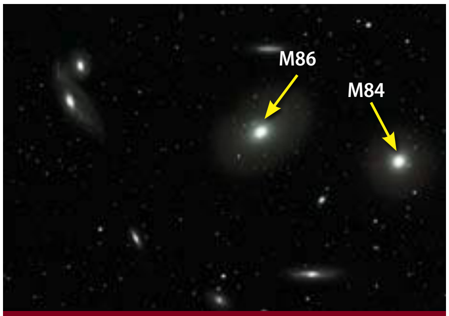
Challenge yourself and your equipment by targeting some faint but fascinating galaxies. /// BY STEVE COE

Explore the Virgo cluster

Any star chart that plots deep-sky objects shows the constellation Virgo the Maiden is chock-full of galaxies. Most make worthy targets for 8-inch or larger telescopes, but where to start? I've found the best approach is to work your way from one edge of Virgo to the other. So point your telescope at the constellation's western side (which rises first), and, from there, we'll head east. I'll describe some of my favorite galaxies here. (The detailed finder chart on page 70 includes 10 other galaxies in this part of the sky that are worth hunting down.) I made all of my observations with a 13-inch f/5.6 Newtonian reflector unless noted.

NGC 4216 is a beautiful spiral galaxy seen edge-on. It shines at magnitude 10.3. Through my scope, it looks bright and large. This elongated galaxy stretches 4 times as long as wide, just off a north-south line. At 100x, it shows a bright middle. Within a 30' field of view, you'll spot two other edge-on spirals.

The northernmost is **NGC 4222**, just over the border in neighboring Coma Berenices. It appears faint, small, elongated, and no brighter in the middle. NGC 4222 is a low-surface-brightness galaxy, so averted vision helped me spot it. The other field galaxy, **NGC 4206**, looks similar to NGC 4222 except it's somewhat brighter in the middle. This region of sky — with NGC 4216 in the center of an array of spindle-shape galaxies — fascinates me.



GALAXIES ABOUND within the Virgo cluster. This image shows the western central region. In all, the Virgo cluster contains some 2,000 galaxies. The two bright elliptical galaxies above are M86 (above center) and M84. NOAO/AURA/NSF

Like virtually all the objects on the Messier list, spiral galaxy **M61** appears bright and large through a telescope. The brightness of these objects is, after all, the appeal of observing the galaxies Messier cataloged. M61 looks irregularly round. It's much brighter in the middle and displays a distinct nucleus at 150x. The arms are mottled and, in moments of good seeing, you may spot some spiral structure. The NGC description for this galaxy uses the term "biN," which means "binary nucleus."

Increasing the power to 220x and covering my head with a dark cloth showed the dual nature of this galaxy's core. I saw two bright areas in the middle easily with direct vision. When I used averted vision at this power, the spiral arms sparkled.

Try using an 8-inch scope to spot two of M61's companions. **NGC 4301** is faint, small, round, and evenly illuminated. Averted vision helps pick out this magnitude 13.6 galaxy. **NGC 4303A** is fainter, small, slightly elongated, and also less bright in the middle. Both galaxies lie about 10' from M61, so a medium-power eyepiece comfortably shows all three.

Viewing the elliptical galaxy **M84** takes us to our first object within Markarian's Chain, a prominent arc of galaxies that loops about 3° to the northeast. Markarian's Chain ranks as one of the most memorable large-scale features in the sky. My 8x42 binoculars frames this region perfectly. True, I can see "only" 10 galaxies, but it's fun to realize that with small binoculars, you can see out to 50 million light-years.

M84 shines at magnitude 9.1. It appears large, irregular, and a bit elongated at 100x. It's also bright in the middle at 100x. Increase the magnification to 150x, and you'll see this galaxy's elongation better. However, no amount of power will show any detail in this elliptical galaxy; galaxies without spiral arms rarely show mottling.

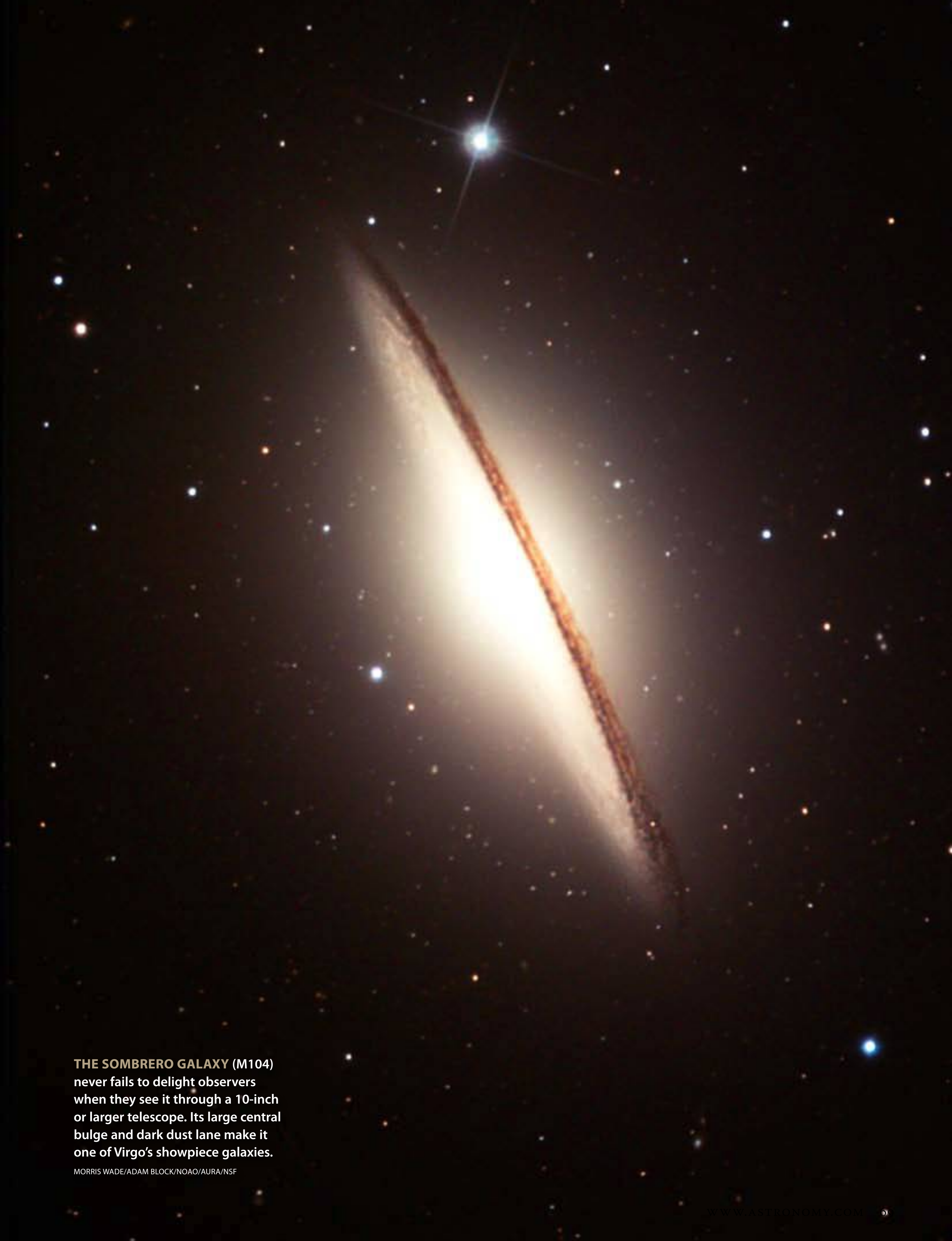
NGC 4388 lies 16' southeast of M84. NGC 4388 is a lens-shape galaxy that shares the field with M84 and M86 at the start of Markarian's Chain.

NGC 4388 glows at 11th magnitude, appears large, and has a bright middle at 100x. It measures 3 times as long as wide, on an east-west line. I used magnifications up to 220x in an attempt to see some of this galaxy's bizarre distortions that show up in photographs. I could see only that the central section looks lenticular, and the outer arms appear mottled.

NGC 4435 and **NGC 4438** form a galaxy pair 23' east of M86. NGC 4438, at magnitude 10, is the larger and brighter of the two. About 4' separate this pair. NGC 4435 shines at magnitude 10.8 with a bright middle. The galaxy is elongated 2 to 1 along a north-south line.

NGC 4438 appears more elongated, also along a rough north-south line. It has a bright middle with an almost stellar nucleus and appears somewhat mottled at

Steve Coe *is a member of Phoenix's Saguaro Astronomy Club. His book,* Observing Nebulae, *will be published by Springer Verlag in 2006.*



THE SOMBRERO GALAXY (M104) never fails to delight observers when they see it through a 10-inch or larger telescope. Its large central bulge and dark dust lane make it one of Virgo's showpiece galaxies.

MORRIS WADE/ADAM BLOCK/NOAO/AURA/NSF

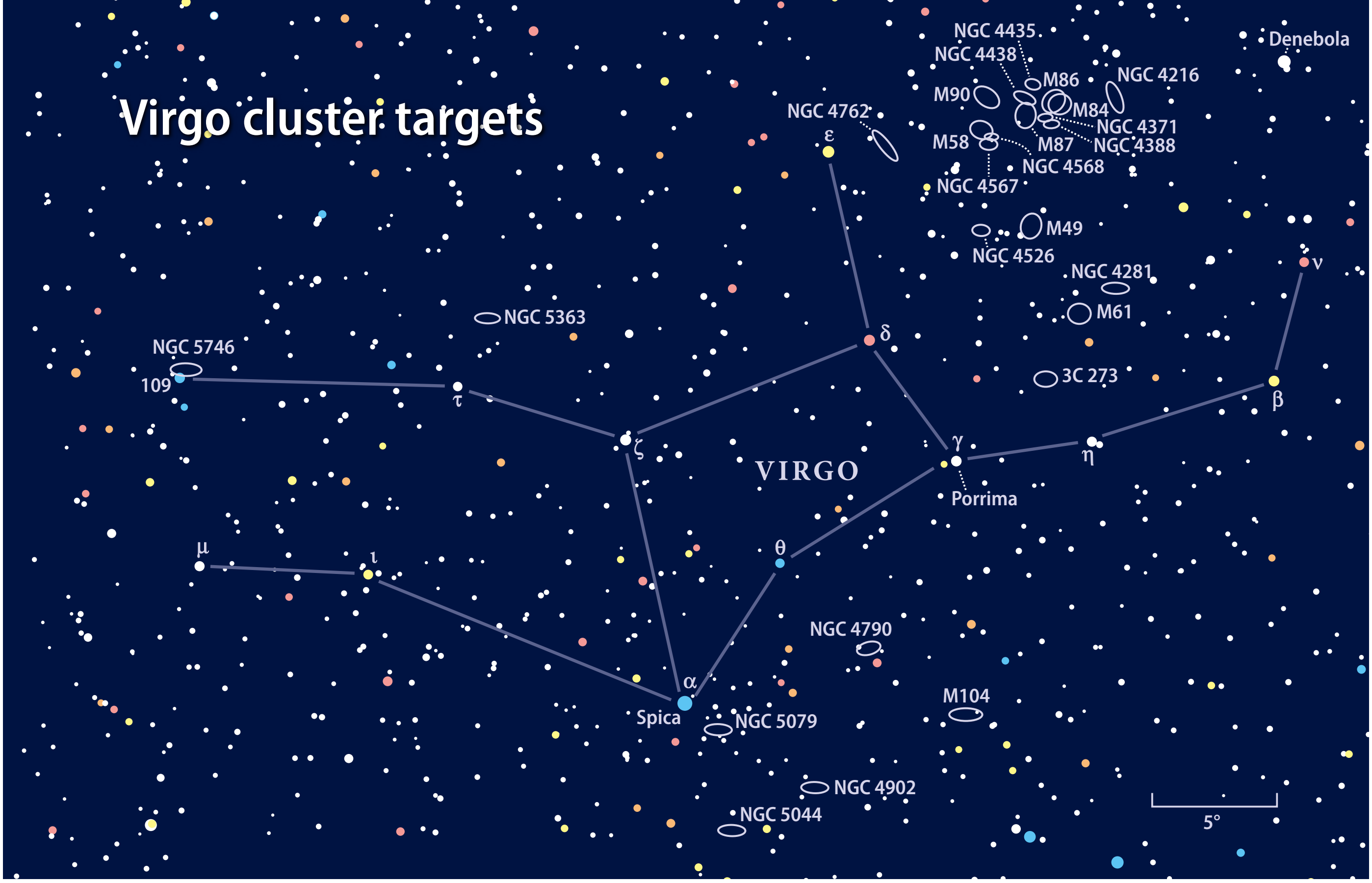


PHOTO CREDIT

150x. For me, this pair of galaxies is one of the guideposts along Markarian's Chain — it lets me know where I am in Virgo.

Next is the giant elliptical galaxy **M87.** We have left Markarian's Chain and moved to the south. M87, at magnitude 8.6, is Virgo's brightest galaxy. At 100x, it looks bright, large, and round. This huge galaxy is brighter in the middle and shows three levels of condensation across a smooth surface. Don't look for mottling in this elliptical galaxy, but the three layers of brightness stand out. A bright, small core measures 10", and around that core is a layer about 2' across. The outer section is the faintest part — it makes the total galaxy about 5' in diameter.

Enjoy observing several galaxies in the same field of view. M87 has four companion galaxies when viewed at 150x. **NGC**

LOCATION, LOCATION, LOCATION

It can't be chance that so many of these huge conglomerations of stars, dust, and gas we call galaxies lie in one part of the sky. One reason Virgo lies bloated with galaxies is its direction — specifically, away from the Milky Way. In addition to stars, the Milky Way contains lots of dust and gas. Pointing your binoculars or telescope at it will show you plenty of star clusters and nebulae, but few galaxies that lie beyond it. It's like trying to see one person on the far side of a crowded room.

Constellations far from the Milky Way's path show lots of galaxies. During spring in the Northern Hemisphere, those constellations are Leo, Virgo, Coma Berenices, Canes Venatici, and Ursa Major. During autumn, the galaxy-rich constellations are Cetus, Eridanus, and Piscis Austrinus.

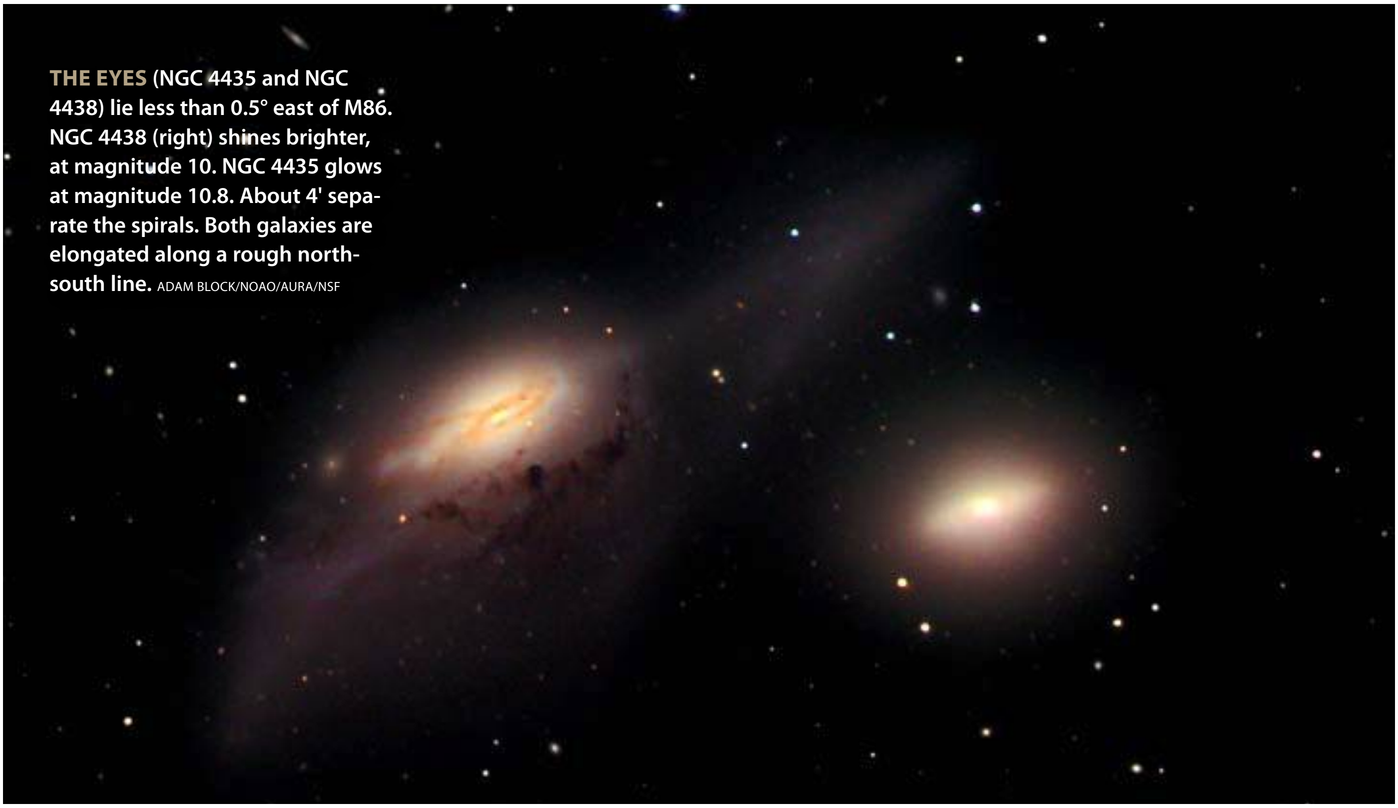
So, we expect to find lots of galaxies in Virgo, but another factor adds to the number — the location of our galaxy relative to this region. The Milky Way lies about 60 million light-years from a huge galaxy group called the Virgo cluster, which is centered near Virgo's giant elliptical galaxy M87. The cluster contains about 200 bright galaxies and several thousand fainter galaxies down to magnitude 16.

Some findings from the ROSAT X-ray satellite show three centers to the hot gas swirling within the Virgo cluster. Three galaxies lie at those points: M49, M86, and (no surprise) M87. Astronomers interpret these results to mean the Virgo cluster's member galaxies did not form at the same time, but they collapsed during a period of many hundreds of millions of years. — *S. C.*

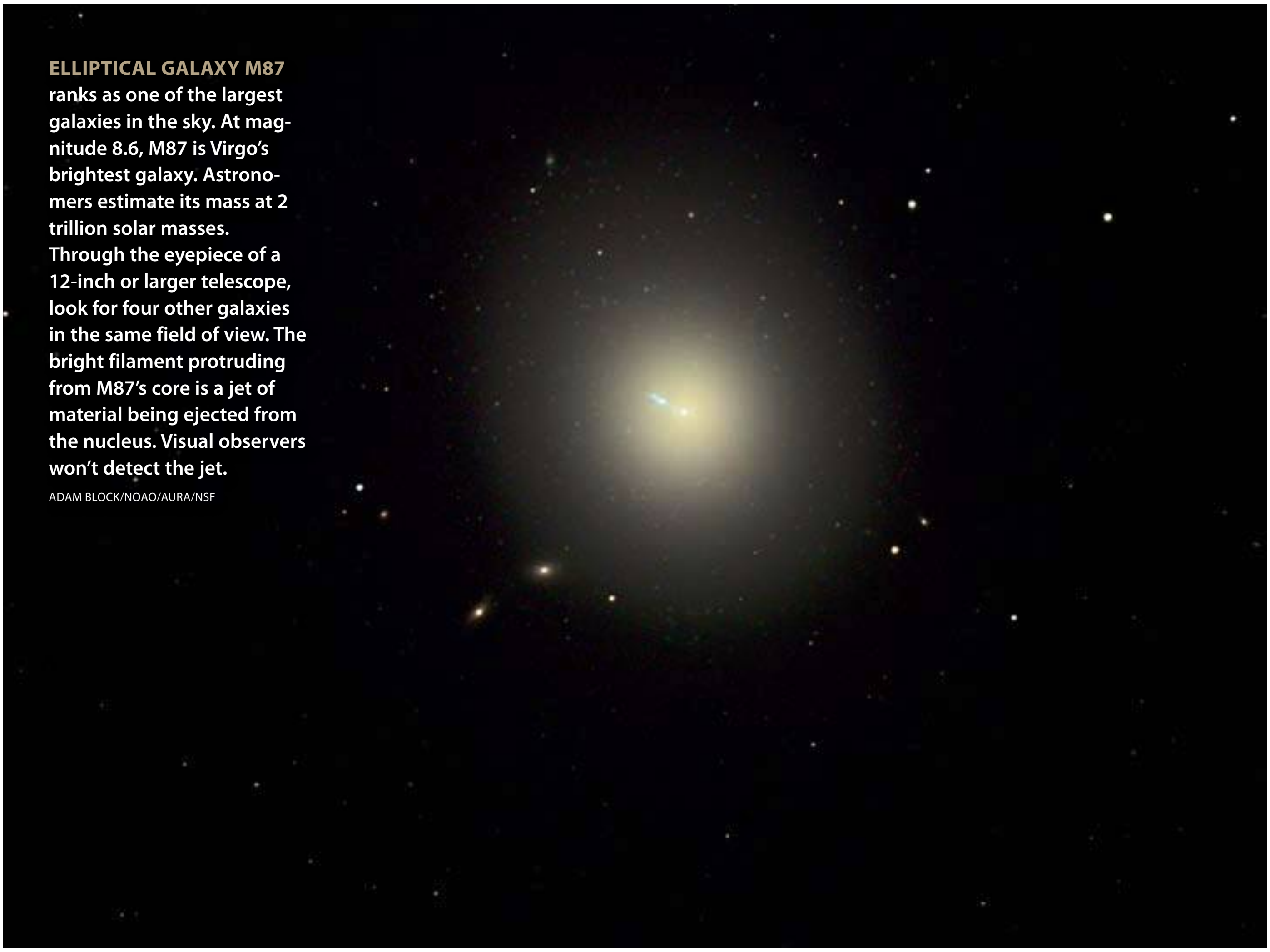
TWENTY-FIVE GALAXIES will keep you and your telescope busy this spring. For best results, observe from a dark site.

GALACTIC GLOSSARY

AVERTED VISION	looking slightly away from a small, faint object to use a more light-sensitive part of the eye
CONDENSATION	a galaxy's level of brightness due to star density
MOTTLING	grainy appearance
NGC OBJECT	stands for *New General Catalogue*; one of 7,840 deep-sky objects cataloged in 1888 by English astronomer John Louis Emil Dreyer
NUCLEUS	a galaxy's core, usually the brightest part of the galaxy
SEEING	a measure of the atmosphere's steadiness
TRANSPARENCY	a measure of the atmosphere's clarity

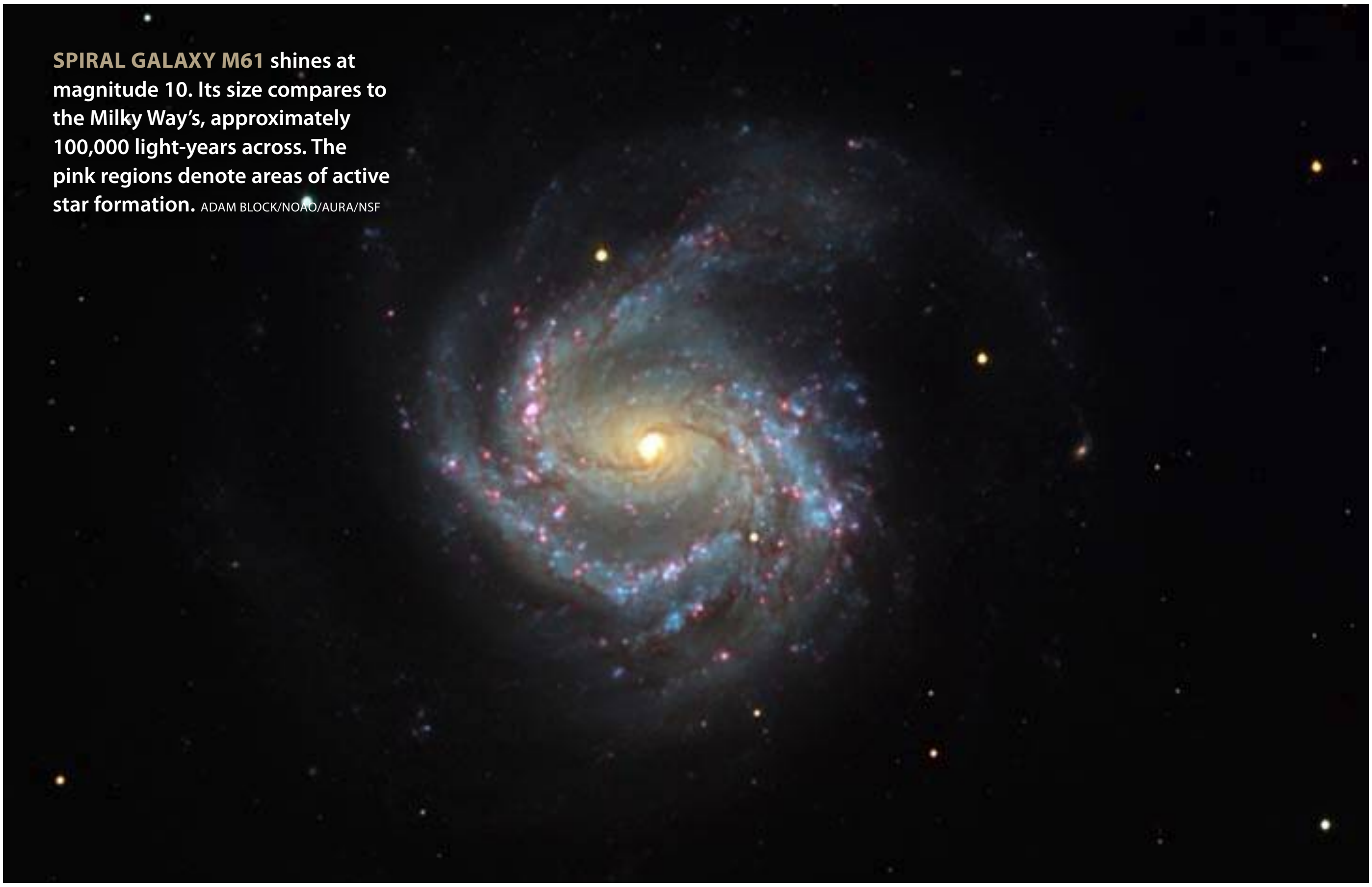


THE EYES (NGC 4435 and NGC 4438) lie less than 0.5° east of M86. NGC 4438 (right) shines brighter, at magnitude 10. NGC 4435 glows at magnitude 10.8. About 4' separate the spirals. Both galaxies are elongated along a rough north-south line. ADAM BLOCK/NOAO/AURA/NSF

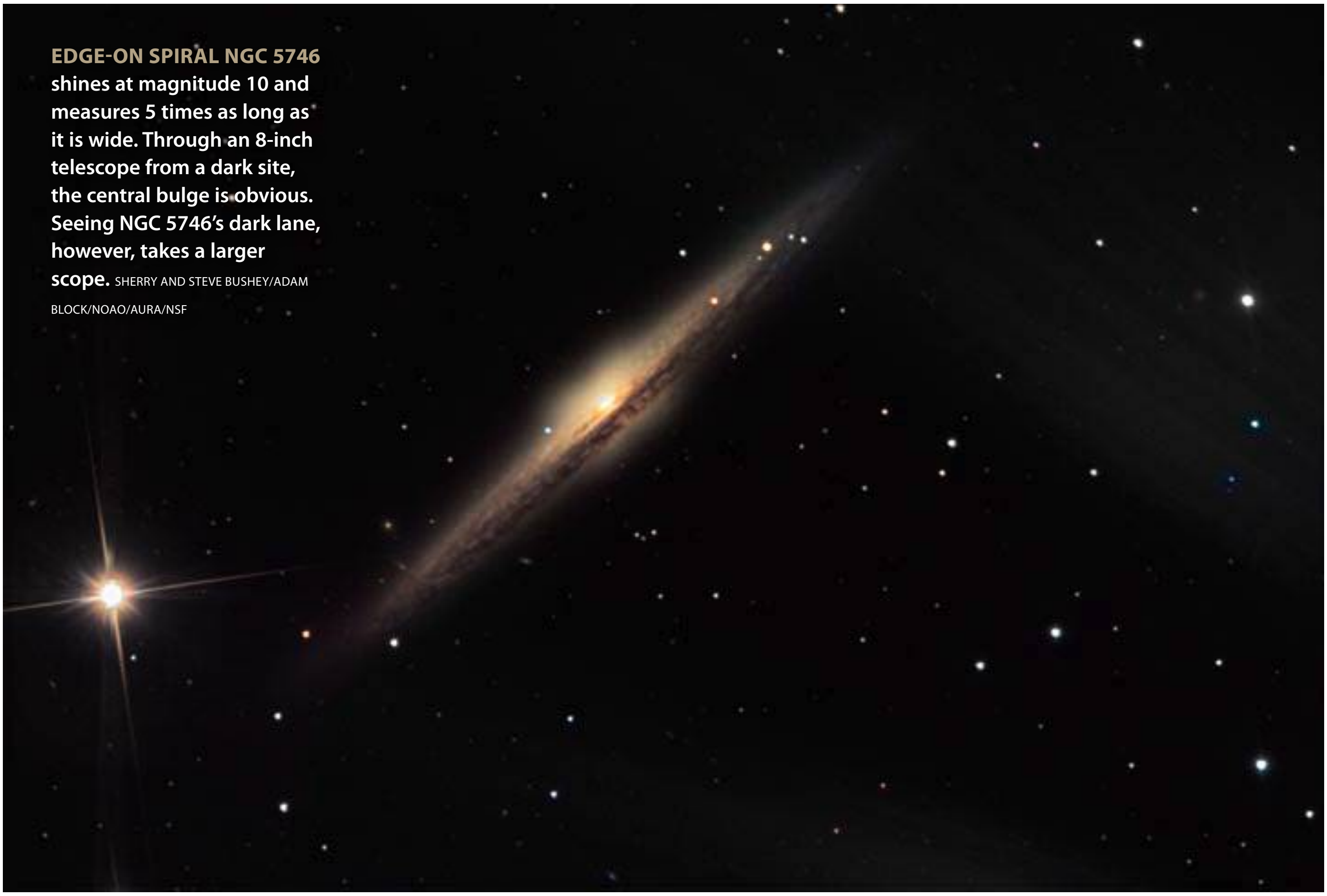


ELLIPTICAL GALAXY M87 ranks as one of the largest galaxies in the sky. At magnitude 8.6, M87 is Virgo's brightest galaxy. Astronomers estimate its mass at 2 trillion solar masses. Through the eyepiece of a 12-inch or larger telescope, look for four other galaxies in the same field of view. The bright filament protruding from M87's core is a jet of material being ejected from the nucleus. Visual observers won't detect the jet.

ADAM BLOCK/NOAO/AURA/NSF



SPIRAL GALAXY M61 shines at magnitude 10. Its size compares to the Milky Way's, approximately 100,000 light-years across. The pink regions denote areas of active star formation. ADAM BLOCK/NOAO/AURA/NSF



EDGE-ON SPIRAL NGC 5746 shines at magnitude 10 and measures 5 times as long as it is wide. Through an 8-inch telescope from a dark site, the central bulge is obvious. Seeing NGC 5746's dark lane, however, takes a larger scope. SHERRY AND STEVE BUSHEY/ADAM BLOCK/NOAO/AURA/NSF

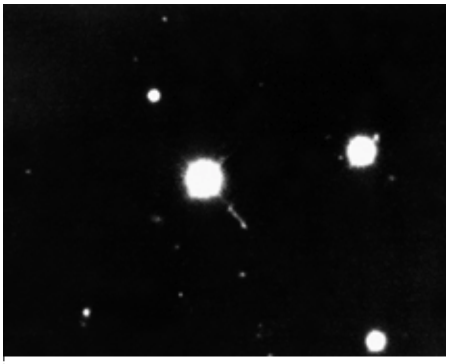
/// MORE GALACTIC TREATS IN VIRGO

Object	Type	R.A.	Dec.	Magnitude	Size
NGC 4281	Sa	12h20m	5°23'	11.3	3' by 1.6'
NGC 4371	SBO	12h25m	11°42'	10.8	4' by 2.3'
M49	E	12h30m	8°00'	8.4	9.8' by 8.2'
NGC 4526	SBO	12h34m	7°42'	9.7	7' by 2.5'
M90	SB	12h37m	13°10'	9.5	9.9' by 4.4'
M58	SB	12h38m	11°49'	9.7	6' by 4.8'
NGC 4762	SB	12h53m	11°14'	10.3	8.6' by 2'
NGC 4790	SB	12h55m	–10°15'	12.1	1.5' by 0.9'
NGC 4902	SB	13h01m	–14°31'	10.9	2.9' by 2.6'
NGC 5044	E	13h15m	–16°23'	10.8	2.6' by 2.6'
NGC 5079	SB	13h20m	–12°42'	12.0	1.5' by 0.8'
NGC 5363	Sa	13h56m	5°15'	10.1	4.6' by 3.1'

Key: R.A. = Right ascension (2000.0); Dec. = Declination (2000.0); Magnitude = Visual magnitude; Size is estimated — larger telescopes will show more of a galaxy's outer region; E = elliptical; Sa = tightly wound spiral; SB = barred spiral; SBO = transitional class between ellipticals and barred spirals

KEN SIARKIEWIEZ/ADAM BLOCK/NOAO/AURA/NSF

NGC 4216 is the largest and brightest of a group of three galaxies you'll see through an 8-inch telescope using a medium-power eyepiece. All three galaxies are spindle-shape spirals seen edge-on.



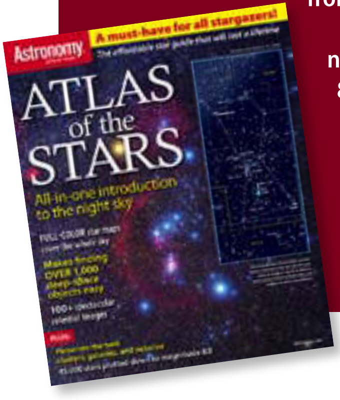
ALAN AND LYNN GINGRICH/ADAM BLOCK/NOAO/AURA/NSF

QUASARS LIKE 3C 273 (center) are superluminous objects. 3C 273 emits 100 times the energy of a normal galaxy and lies roughly 2 billion light-years away. Through a telescope, you'll see only a star-like point glowing at magnitude 12.7.

4486A glows at magnitude 11 and lies about 7' south of M87. It appears faint, small, round, and bright in the middle. **NGC 4486B** sits north of M87, about the same distance as NGC 4486A. NGC 4486B is faint, small, and elongated east-west. I observed this magnitude 13.4 galaxy with averted vision only on a night with excellent transparency.

The next two galaxies lie west of M87. **NGC 4478** sits 4.5' distant. Through the scope, it appears round and a little brighter in the middle. **NGC 4476** is about 9' from M87, and it shines at magnitude 11.4. Through my 13-inch reflector, it looked about 50-percent longer than wide with a bright middle.

To help you find your way through the Virgo cluster and the rest of the sky, check out *Atlas of the Stars*, the new celestial guide available May 18, 2006, from *Astronomy*. Order yours now by calling 800.533.6644 or log on to www.astronomy.com.



Astronomy
A must-have for all stargazers!
ATLAS of the STARS
All-in-one introduction to the night sky

NGC 4567 and **NGC 4568** form one of the most famous galaxy pairs: the Siamese Twins. Both appear bright, large, and elongated roughly twice as long as wide. The northernmost, NGC 4567, has a brighter middle. The two galaxies form an obvious 60° "V" shape. Images of these galaxies show them passing close to each other (their apparent separation is about 1'), but their outer spiral arms remain undistorted. Either they will miss each other or they haven't started interacting.

Next, we arrive at the star of the show — the **Sombrero Galaxy** (M104). You've probably seen a photograph of this memorable galaxy and its dark equatorial dust lane. Indeed, it does look like a sombrero with a wide band.

Pick a dark night far from city lights, and the Sombrero will provide you with a view that will bring a smile to your face. On such a night, I saw M104 easily through my 11x80 finder scope, and it even looked elongated at this low power. At 100x through the main scope, M104 looked bright, large, elongated 4 times longer than wide in an east-west direction, and brighter in the middle. The bright core sits on the northern edge of the dark lane. A magnification of 150x provides an excellent view; averted vision doubles the galaxy's size. A magnitude 13 star lies to the north, centered above the core. Increasing the power to 220x shows a little scalloped detail in the dark lane's edges.

At the eastern end of Virgo lies edge-on spiral galaxy **NGC 5746**. This magnitude 10 galaxy looks bright, large, and has a bright middle at 135x. NGC 5746 appears 5 times as long as it is wide. The central bulge is obvious, and a dark lane cuts across the galaxy during moments of good seeing. Averted vision makes NGC 5746 grow noticeably longer and also shows a faint star attached to the southern arm.

Every good observing list needs a challenge, and Virgo provides plenty. Try to find **3C 273** — the brightest quasar (and also the first one to be discovered).

To locate this magnitude 12.7 object, use the finder chart on page 68. The only telescope I've seen it through was a 17.5-inch reflector at 200x. A smaller scope will reveal it, but a faint star lies nearby, and I needed a big scope for confirmation.

The Virgo cluster holds many other galactic treasures I haven't described, but that's the good news. Break out your telescope, pick a bright galaxy, and get started. There's a lot to see.

Made Your Way

How many 25mm Plossls do you need?
No problem.
We exchange, add and install your accessories before you buy. We customize your purchase made your way.

Pick the finder you want
Select your favorite eyepiece
Make your diagonal 2" or 1.25"
Try an Aluminum, Wood or Steel Tripod
We offer 5 power sources

Hands on Optics
26437 Ridge Road, Damascus, Maryland 20872
www.handsonoptics.com
1-866-726-7371

The Celestron SkyScout Personal Planetarium is Way Cool!

optcorp.com

PREMIER SELECT CELESTRON DEALER

- The SkyScout is an innovative, lightweight hand-held device that instantaneously identifies and/or locates over 6,000 objects in the night sky!
- No set-up necessary! It not only identifies the object you are looking at, but provides scientific information in audio & text format on those objects.
- Available soon!
- Order today for earliest delivery!

Craig Weatherwax,
"Way Cool Craig",
Founder of OPT

OPT
Oceanside Photo & Telescope
918 Mission Avenue, Oceanside, CA • 1.800.483.6287

JMI The Company To Watch

SAVE BIG $

FREE SHIPPING ON JMI CASES

JMI Cases fit most popular telescopes.

This 14" Case will fit in the back seat of a Toyota Corolla.

MOTOFOCUS
THE PRODUCT THAT PUT AN END TO THE FOCUSING WIGGLES
All 2" focusers and 1-1/4" adapters have internal clamp rings.

Hand control starts out slow, ramps up, stops on a dime.

14" LX200 GPS Carrying Case
SAVE $58 ON FREE SHIPPING
Padded Handles fold away for storage
10" Pneumatic Tires recessed for low profile.

NOT ALL FOCUSERS ARE CREATED EQUAL!!

JMI'S NGF FOCUSERS GIVE YOU WHAT OTHERS DON'T OR CAN'T OR WON'T GIVE YOU.

- Brass clamping rings on 2" drawtubes
- Brass clamping rings on 1-1/4" adapters
- 48mm filter threads on 1-1/4" NGF adapters
- 8-pound lifting power, twice as much as some
- MOTOFOCUS compatible
- Digital Focus Counter compatible
- Digital Read Out compatible
- Automatic Smart Focus compatible
- Dual-Speed Knobs on DX1, 13 times finer than most Rack-and-Pinion focusers
- All this in a low-profile focuser and no unsightly springs
- Starting at $69

"The whole amateur community owes companies like yours a very great deal. Uncompromising quality at the cutting edge..." *J. Kirkland*

"Just a brief note to tell you how happy I am with the recent purchase of the JMI MOTOFOCUS...I am usually far to busy to send an email like this unless the product really did exceed all expectations..." *C.E.S. Dewar*

Order Now!
1-800-247-0304
Visa & Mastercard accepted.

Prices are subject to change.

JMI Telescopes - Jim's Mobile, Inc. - 8550 W 14th Ave - Lakewood, CO 80215 - U.S.A. - Info 303-233-5353 - Fax 303-233-5359 - Orders 800-247-0304 - info@jmitelescopes.com

©2006 ADORAMA INC.
Source for the Educated Photographer
info@adorama.com • www.adorama.com
Order Toll Free: 800-223-2500

PREMIER SELECT CELESTRON DEALER

New
CPC 8 XLT
$1999.00
IN STOCK

NexStar 8i Special Edition
New Nexstar 8 I SE
Includes XLT Coatings
SkyAlign
$1399.00
IN STOCK

ADVANCED SERIES

New C80 ED Refractor 799.00
New C100 ED Refractor 1299.00
New C130 ED Reflector 699.00
C6-R 6" Refractor 849.00
C6-N 6" Newtonian 399.00
C8-N 8" Newtonian 699.00
C10-N 10" Newtonian 909.00
C9¼-S 9.25" SCT 1469.00
C11S-SGT w/XLT (SCT) 1977.00

ADVANCED COMPUTERIZED

New C80 ED Refractor 1099.00
New C100 ED Refractor 1574.00
New C130 ED Reflector 1029.00
C6-R-GT 6" Refractor 1069.00
C8-N-GT 8" Newtonian 1019.00
C10-N-GT 10" Newtonian 1199.00
C8-S-GT 8" SCT 1399.00
C9¼-S-GT 9¼" SCT 1779.00
C11-SGT w/XLT (SCT) 2279.00

Reducer/Corrector F/6.3 $114.95

NEW NEXSTAR SLT

Nexstar 60 ......279.00
Nexstar 80 ...379.00
Nexstar 102 ....479.00
Nexstar 114 .399.00
Nexstar 130 ....439.00

FIRSTSCOPE SERIES

Firstscope 114 EQ 189.95
Firstscope 114 EQ Short 139.95

CGE SERIES

800 XLT 3654.00
925 XLT 4019.00
1100 XLT 4424.00
1400 XLT 6134.00

NEW CPC SERIES

CPC 8 1899.00
CPC 8 XLT 1999.00
CPC 9.25 2349.00
CPC 9.25 XLT ...2499.
CPC 11 2599.00
CPC 11 XLT ......2799.

CELESTRON TELESCOPE ACCESSORIES

NexImage
Solar System Imager

$99.95

NEXIMAGE ACCESSORIES

UV/IR CUT OFF Filter 52.95
Neximage Reducer 21.95
2x Ultima Barllow Lens 60.95

CELESTRON FILTERS

OXY III 1¼" 64.95
OXY III 2" 88.95
UHC/LPR 1¼" 59.95
UHC/LP2 2" 79.95
Contrast-Booster Filter - 1-1/4" 39.95
Polarizer Set 1¼" 29.95
Sky Filter #2 ....29.95
4 piece 1.25" Filter Set 34.95

DIAGONALS

Diagonal Erect 1¼" 45º 34.95
Hybryd Diagonal .96" 1¼" 45º 34.95
Diagonal Erect 1¼" 90º 34.95
Star Diagonal 1¼" 90º 33.95
2" Mirror Star Diagonal 74.95
New Stereo Binocluar Viewer 189.95

ULTIMA EYEPIECES

5mm, 1¼" 73.95
7.5, 1¼" 73.95
10mm 73.95
12.5mm, 1¼" .73.95
18mm 1¼" 73.95
30mm, 1¼" 88.95
42m, 1¼" 89.95
35m 1¼" 94.95
2X Ultima Barlow Lens 60.95

E-LUX SERIES 1.25" EYEPIECES

6, 10, 25mm, .26.95
40mm, ...39.95

E-LUX SERIES 2" EYEPIECES

26mm 49.95
32mm 54.95
40mm 64.95

OMNI SERIES 1.25" EYEPIECES

4,6,9,12.5,15,20,25mm 32.95
32, 40mm 43.95
Omni 2x Barlow 39.95

BINOCULARS

SKYMASTER

12x60 ....**56.95**
15x70 ....**64.95**.
20x80 ....**199.95**
25x100 ....**Call**

X-CEL SERIES 1.25" EYEPIECES

2.3mm, 5mm, 8mm, 10mm, 12.5mm, 18mm, 21mm, 25mm 55.95
2x 1¼ ED Barlow 63.95

AXIOM EYEPIECES

19mm 1¼" 134.95
23mm 1¼" ...149.95
19mm 2" 169.95
34mm 2" 209.95
40mm 2" 254.95
50mm 2" 274.95

MOUNTS

Upgraded CG-5 Mount 369.95
CG-5 Computerized mount 699.95
Vibration Suppression Pads 39.95

ACCESSORY KIT

Includes: • 5 Superior Grade Plossl Eyepieces 1.25"(4mm, 6mm, 9mm, 15mm, & 32mm), • 2x Barlow Lens, • Six Colored Filters, • Moon Filter, • Aluminum Carrying Case

All for only $129.95

NEW ACCESSORY KIT

Includes: • 3-2" Eyepieces, 2" 5 Color Filters, 2"Star Dia, 2" 2X Barlow Aluminum Case $239.95

CELESTRON SKYSCOUT

SKYSCOUT PERSONAL PLANETARIUM

Introducing the SkyScout from Celestron:
The SkyScout is a revolutionary, one of a kind, patented handheld device that instantly identifies and/or locates any celestial object visible to the naked eye, providing educational and entertaining information, both in text and audio.

A fun learning tool for all ages, the SkyScout personal planetarium puts the knowledge of an expert astronomer in the palm of your hand.

Item Includes: Carry Case, Earphones, Hand Strap, USB Cable

$399.95

THE ULTIMATE IN PHOTO SHOPPING:
www.adorama.com

MEADE

NEW

We stock the complete line of **Meade** accessories

see our web site for details

DEEP SKY IMAGER II / PRO II

Deep Sky Imager II (CLR)	$599.00
CCD Color Filter Set	$199.00
Deep Sky Imager Pro II	$599.00
Deep Sky Imager Pro II w/RGB	$699.00

- **Dramatically lower noise**
- **Larger (1/2" chip)**
- **74% Higher resolution (752x582)**
- **Greater sensitivity**
- **Temperature sensor**

NEW! LX90 GPS SERIES

The Meade 8, 10, & 12" LX90
Includes with MgF2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally).

Camera Adaptable

KEY FEATURES

- GPS & Level North Technology
- Smart Drive, Autostar Controller
- Oversize Primary Mirror, Diffraction - Limited Optics
- Rigid Cast Aluminum Fork Mount
- LX-200 Series Tripods
- Smart Finder (Red Dot) & 8x50 View Finder
- AutoStar Suite Astronomer's Edition Software

LEVEL NORTH™ TECHNOLOGY

LX90	Price
8" w/UHTC	$2,074.00
10" w/UHTC	$2,734.00
12" w/UHTC	$3,294.00

PRICES INCLUDE SHIPPING

SCT TELESCOPE ACCESSORIES

#62 T-Adapter	$26.95
Variable Projection Tele-Extender	$39.95
#895 Vibration Iscolation Pads	$49.95
F/6.3 Focal Reducer/Flattener	$129.95
F/3.3 Focal Reducer/Flattener	$149.95
#777 Off-Axis Guider	$79.95
#644 Flip-Mirror System (1.25") w/UHTC	$149.95
#647 Flip-Mirror System (1.25"/2") w/UHTC	$249.95

ETX PREMIER EDITION

Automatic Alignment + SmartFinder
Meade's new ETX-Premier Edition automatically levels your telescope, points it to North and sets the time.
You just enter your location or zip code. After your ETX completes its patented Level North automatic alignment procedure it will point to the first alignment star. Use the new wide-field SmartFinder to center the red dot over the alignment stars for ultra-precise pointing accuracy. It's that easy.

Camera Adaptable

KEY FEATURES

- Electronic Level Sensor
- Electronic Magnetic North Sensor
- High Precision Internal Clock
- Red Dot Viewfinder (SmartFinder™)

ETX PREMIER	Price
90 PE w/UHTC	$749.00
105 PE w/UHTC	$974.00
125 w/UHTC	$1,194.00

PRICES INCLUDE SHIPPING

LEVEL NORTH™ TECHNOLOGY

ETX TELESCOPE ACCESSORIES

#932 Erect Image Diagonal	**$49.95**	#505 Cable	**$24.95**
#895 Vibration Iscolation Pads	**$49.95**	#126 2x Barlow	**$47.95**
#541 A/C adapter	**$49.95**	#64 T-Adapter	**$34.95**

LIGHTBRIDGE DOBSONIANS

KEY FEATURES

FEATURES	STANDARD	DELUXE
Diffraction Limited Optics	•	•
Meade Optical Coatings	•	•
2" Crayford-Style machined aluminum focuser w/1.25" adapter	•	•
Red Dot Finder	•	
Advanced Red-Dot Finder (includes four reticles)		•
Steel RA roller bearings		•
26mm Series 4000™ Super Plossl Eyepieces	•	
26mm QX™ Wide Angle 2" Eyepiece (70" field-of view)		•
Built-in Primary Mirror Cooling Fan	•	•

STANDARD	PRICE
8"	$469.00
10"	$649.00
12"	$949.00

PRICES INCLUDE SHIPPING

DELUXE	PRICE
8"	$569.00
10"	$749.00
12"	$1,049.00

STAR-BOUND *Viewing Chair*

THE PERFECT CHAIR FOR ASTRONOMY VIEWING COMFORT

ADJUSTABLE FROM 9"-32", FOLDS FLAT, POWDER COATED WHITE OR BLACK

$159.00

WILLIAM OPTICS

New Zenithstar 66 ED (TRI) APO	498.00
New Zenithstar 66 semi APO	298.00
New Zenithstar 80 semi APO Kit	498.00
New Zenithstar 80 Short Tube Kit	498.00
97% Reflective Rate Star Diag. f/SCT	139.00
99% Reflective Rate 2 Inch Star Diag.	198.00
45 Degree 1.25" Erecting Prism	99.00
New 45 Degree 2" Erecting Prism	198.00
New Binoviewer w/20mm WA E.P.	199.00

ASTRONOMY BINOCULARS

Great for viewing The Heavens

Nikon PENTAX
FUJINON Canon
MEADE

We Stock The Complete

Tele Vue

Check Our Web Site for a Full Listing

Canon

NEW

EOS-20Da Digital Astrophotography SLR Camera Body Kit - USA Warranty

$2199.00

KENDRICK ASTRO INSTRUMENTS **Dew Control System, Heaters, Solar Filters, Laser Collimators, Astronomy Tents.**

TAKAHASHI

FS-60, Sky-90, FS-102, FSQ-106, TOA-130, LE Eyepieces, **IN STOCK!**

Check Our Web Site
For Details www.adorama.com

CORONADO

PST, SolarMax
40 Telescopes,
60 & 90mm systems

Check Our Web Site for a Full Listing

Vixen

Stocking Dealer

SPHINX MOUNT

Check Our Web Site for a Full Listing

RIGEL SYSTEM

Star Lite LED
$26.95

Sky Lite LED..........34.95
Puls Guide..........38.95

QUICK FINDER

- **Compact Design**
- **Projects 1/2 and 2 Degree Red circles**
- **Pulsed or Continuous Illumination of Reticle**
- **Two Baseplates**

$34.95

TELRAD FINDER

TELRAD with Base	36.95	Extra Mounting Base	7.95
Dew Shield for Telrad	13.95	Dew Shield +	24.25

JMI FOCUSERS

NGF-DX1	233.00	NGF-C	149.95
NGF-CM w/Motofocus	244.95	NGF-DX2	180.00
NGF-DX3	144.00		

LUMICON

	1.25"	2"	Rear Cell
Deep Sky	99.95	199.95	199.95
UHC	99.95	199.95	199.95
Oxygen III	99.95	199.95	199.95
H-BETA	99.95	199.95	199.95
1.25" Lumibrite Diagonal			149.95
2" Lumibrite Diagonal			239.95
Multiple Filter Selector			129.95
50mm Right Angle Finder Complete			139.95
80mm Right angle Super Finder Complte			299.95

ASTRONOMY SOFTWARE

THE SKY for Windows

Sky 6 Student Edition	Call
Sky 6 Serious Edition	Call
Sky 6 Pro Edition	Call

STARRY NIGHT

Enthusiast V.5.0	59.95
Pro V.5.0	119.95
Pro Plus V.5.0	189.95

WE SHIP PROMPTLY ALL TELESCOPES INCLUDE U.S.A. WARRANTY

No Surcharge for MasterCharge or Visa Purchases. Personal checks welcome, will ship without delay. Name must be imprinted on check, also include address, phone, and a copy of major credit card or driver's license for reference. Shipping, handling and insurance additional. 14 day money back guarantee less shipping, with packing and blank warranty card, except film and paper. We ship UPS. Some items special order. All orders are subject to acceptance and verification. Second hand dealer's license #802862. Pictures are for illustration purposes only and may not be exact. **Prices effective till April 10, 06** **Please address all inquiries and orders to ASTRO. DEPT. #55**

ADORAMA INC.
Source for the **Educated Photographer**

42 West 18th Street New York, N.Y. 10011 info@adorama.com
www.adorama.com • Order Toll Free USA / Canada 800-223-2500
Orders & Information - 212-741-0052

ASK ASTRO

Astronomy's editors and experts from around the globe answer your questions about the cosmos. This month: the Moon's terminator, clusters vs. dwarf galaxies, and the HUDF's hidden galaxies.

LUNAR SHADOWS

Q: What is the speed of the Moon's terminator? —

TERRENCE GOLLATA, MANITOWOC, WISCONSIN

A: The terminator is the line separating day from night on a planet or moon. As the changing angles between Sun, Moon, and Earth alter the fraction of the Moon bathed in daylight, the lunar terminator sweeps across the Moon's surface. This creates the familiar cycle of lunar phases.

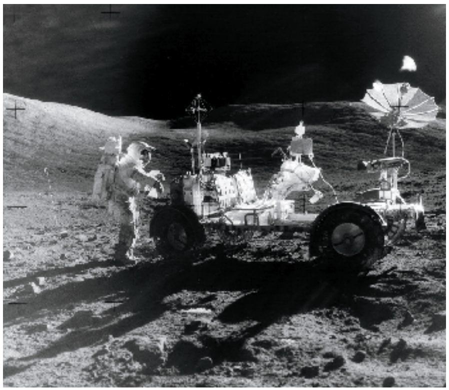
Tides caused by Earth gradually slowed the Moon's spin until its rotation period matched the time it takes to circle Earth. This is why scientists say the Moon is tidally locked, and it's also why the same side of the Moon always faces us. The Moon's surface turns at about 13° per day, or, on average, about ½ a degree of lunar longitude each hour. The Moon moves against the background stars at the same rate.

Dividing the Moon's equatorial circumference (6,786 miles [10,920 kilometers]) by its rotation period (27.32 days) gives the lunar surface's speed: 10.3 mph (16.7 km/h) at the equator. But Earth's motion around the Sun adds an extra twist to the terminator's speed.

In the time the Moon rotates once, Earth and Moon together have cruised about 1⁄12 of their way around the Sun. Because the lighting gradually changes, the Moon must travel a couple of extra days to recreate the same Sun-Earth-Moon angle. This is why it takes longer for lunar phases to repeat (Full Moon to Full Moon takes about 29.53 days) than it does for the Moon to spin and orbit Earth.

Using this longer interval gives the terminator's equatorial speed: 9.6 mph (15.4 km/h). For the terminator's speed at other lunar latitudes, multiply this figure by the latitude's cosine. For example, midway between the equator and the poles, the terminator moves about 70 percent of its speed at the equator.

For comparison, the lunar rover Apollo astronauts drove on the Moon had a top speed of about 8 mph (12.9 km/h). Although the situation never arose, the rovers weren't fast enough to outrun lunar nightfall at any of the Apollo landing sites. — **FRANCIS REDDY,** ASSOCIATE EDITOR



NIGHTFALL advances across the Moon's equator at a speed of about 9.6 mph (15.4 km/h). NASA's lunar rover couldn't outrace the approaching night at any of the Apollo landing sites. NASA

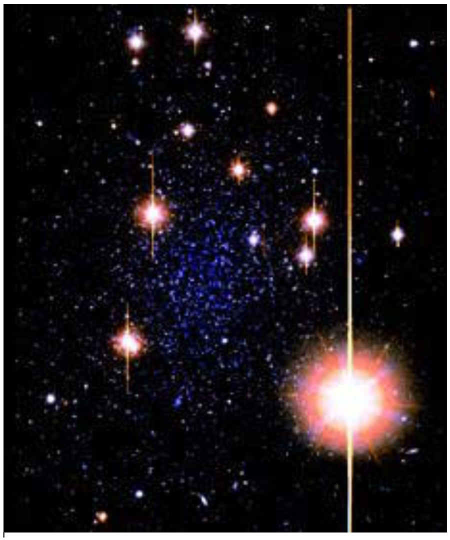
GLOBULARS OR GALAXIES

Q: What's the difference between globular clusters and dwarf spheroidal galaxies?

— **GREG COMEGYS,** CALEDONIA, MICHIGAN

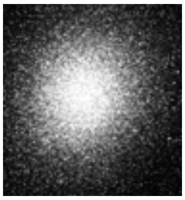
A: In a word: size. Dwarf spheroidal galaxies are much bigger than globular clusters. The Pegasus dwarf spheroidal galaxy, which orbits the famous spiral galaxy M31 in Andromeda, spans 2,000 light-years. A newly discovered object, the Ursa Major dwarf spheroidal (see "New Milky Way satellite," in News, July 2005) is about half this size.

By contrast, a typical globular cluster is roughly 100 light-years in diameter. And some dwarf spherical galaxies, such as Fornax, have their own globular clusters.



E. GREBEL/P. GUHATHAKURTA

THE PEGASUS dwarf spheroidal galaxy (center) measures 2,000 light-years across but is easily lost in the glare of bright stars within our own galaxy. Many astronomers believe faint, low-mass galaxies like this one are the building blocks from which larger galaxies, such as M31 and the Milky Way, may have formed.



GLOBULAR CLUSTER Omega Centauri is the Milky Way's most luminous, containing more than a million stars in a dense ball 150 light-years across. NOAO/AURA/NSF

But while such galaxies are bigger than globular clusters, a dwarf spheroidal's stars are spread over a larger area. The galaxies don't shine as brightly as their size suggests.

In fact, the faintest dwarf spheroidals emit less light than the brightest globular clusters. To illustrate this point, we can compare the absolute magnitudes of the Ursa Major dwarf to that of Omega Centauri, the Milky Way's brightest globular cluster. Using absolute magnitude, which is a measure of an object's intrinsic brightness, astronomers can compare the light output from objects at vastly different distances, like galaxies and globulars.

The Ursa Major dwarf spheroidal has an absolute magnitude of roughly –6.75. But Omega Centauri vastly outshines it. With an absolute magnitude of –10.3, this globular cluster casts 26 times more light into space than the dwarf galaxy. — **KEN CROSWELL,** BERKELEY, CALIFORNIA

HIDDEN IN HUDF

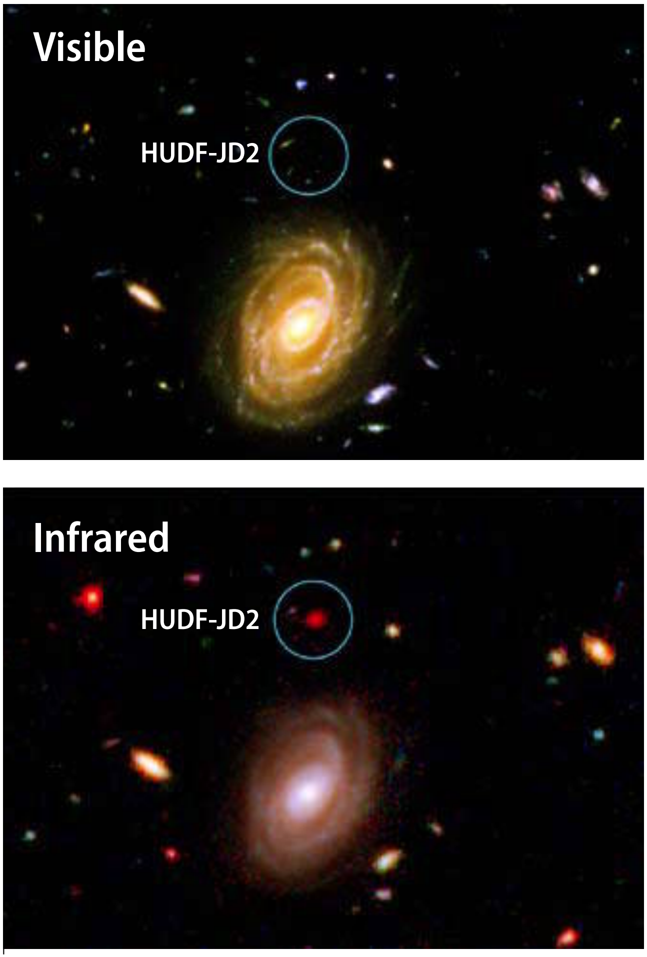
Q: The Hubble Ultra Deep Field seems to have a lot of dark areas in it. With a more powerful telescope, will we find galaxies in them? — **FRANK COULTER,** PAUANUI BEACH, NEW ZEALAND

A: Astronomers believe **there are many more galaxies to be found within the Hubble Ultra Deep Field**, a patch of sky in the constellation Fornax where the Hubble Space Telescope acquired the most penetrating views of the cosmos at visible and near-infrared wavelengths. Unfortunately, the light from more distant galaxies is so redshifted Hubble cannot detect it.

"With the HUDF, we have reached redshifts of 6.7, about 800 million years after the Big Bang," says Sangeeta Malhotra, an astronomer at the Space Telescope Science Institute in Baltimore and lead investigator of two HUDF observing programs. One, called GRAPES (for Grism ACS Program for Extragalactic Science), captured detailed spectra of faint galaxies, allowing direct measurements of their distances (refer to "As far as Hubble can see," November 2005).

"Unfortunately," she says, "this is nearly the limit of what we can do with the current instrument on Hubble. Higher redshift galaxies are even redder, and we need infrared instruments to observe them."

The Hubble Space Telescope will be able to look deeper if NASA decides to go forward with a final servicing mission to upgrade it. One instrument slated to be installed is the Wide-Field Planetary Camera 3. According to Malhotra, the device will see far enough into the infrared to give astronomers access to galaxies at redshift 14, or some 300 million years after the Big Bang.



NASA/ESA/B. MOBASHER (STScI/ESA)

HUDF-JD2, **a massive galaxy discovered in the Hubble Ultra Deep Field, formed in the universe's first 800 million years. There's no trace of the galaxy (circled) in the Hubble Space Telescope's deepest optical-wavelength views, but HUDF-JD2 appears faintly in near-infrared exposures.**

Last September, astronomers came across proof much was going on at this early epoch. A team led by Braham Mobasher of Baltimore's Space Telescope Science Institute and the European Space Agency uncovered a previously unidentified galaxy in near-infrared HUDF exposures.

The galaxy, called HUDF-JD2, contains some 8 times the Milky Way's mass of stars. This challenges the view that all large galaxies were built up gobbling up smaller ones.

What's truly unusual, the team says, is that most of its stars are old and evolved. This means HUDF-JD2 formed rapidly, blazed forth with a massive pulse of star formation, and then, just as fast, shut down its star-making factories. The galaxy managed to do all this, the astronomers say, before the universe was about 800 million years old.

The team estimates HUDF-JD2's distance is between redshifts 6 and 7.5 but concedes current facilities won't be able to nail this down more precisely. — **FRANCIS REDDY,** ASSOCIATE EDITOR

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

IN THE KNOW

DWARF SPHEROIDAL GALAXY
A type of small, diffuse, low-mass, and low-luminosity galaxy.

GLOBULAR CLUSTER
A star cluster with a characteristic elliptical or spherical shape. Globular clusters are densely packed with stars. They're found in both spiral and elliptical galaxies.

TERMINATOR
The line separating day and night on a planet, moon, or other sunlit body.

LUNAR OBSERVING

This month, the Moon climbs farther north than at any time since 1987 and offers observers great views. /// BY MARTIN RATCLIFFE

High Moon

THE MOON puts on a great show this month for imagers and observers alike. MARTIN RATCLIFFE

No high-school-age student has seen a Moon like this. After an 18.6-year trek, Earth's satellite reaches its highest and lowest points in the sky. The last time the Moon appeared at these extremes, Ronald Reagan was president of the United States, stamps were 22 cents, gas was less than a dollar a gallon, and *The Simpsons* was still 3 years from appearing on television.

Astronomers refer to this high Moon as a major lunar standstill. During this event, the Moon reaches higher — and lower — altitudes than normal, depending on its phase and the time of year.

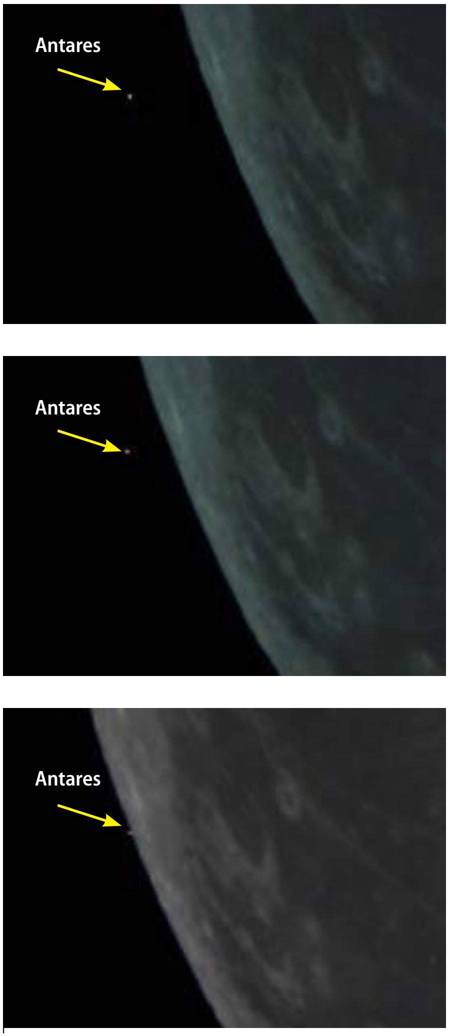
Given the Moon's relative new prominence in the sky, join me on a visual tour of our satellite that includes glimpses of rarely seen lunar regions.

A major lunar standstill

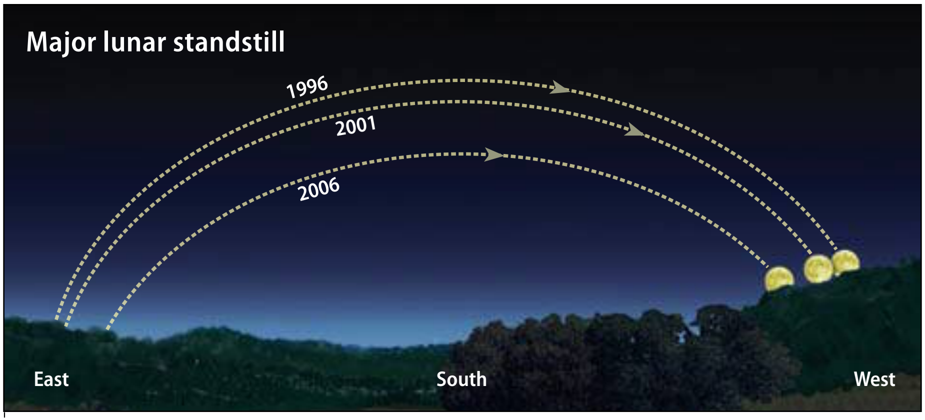
So what's this lunar standstill all about? Consider where the Sun rises throughout the year. At the equinoxes, around March 21 and September 21, the Sun rises due east and sets due west. Between those times, the Sun wanders like a slow pendulum to an extreme northerly limit by June 21, and to a southerly limit December 21, before swinging back to its midpoint again.

Around the summer solstice, the northerly trek of the Sun's rising and setting points slows to a halt, a kind of solar standstill. It's similar to the point a pendulum reaches at the top of its swing. Momentarily, it appears stationary.

The Moon does the same thing, but with one significant variation. Because its orbit tilts about 5° relative to the ecliptic (the apparent path across the sky of the Sun, Moon, and planets), the Moon wanders farther north and farther south than the Sun's rising and setting limits. Such an occasion — a major lunar standstill — occurs in 2006. The wanderings can also be less than those of the sunrise and sunset points, resulting in a minor lunar standstill.



GOING, GOING, GONE. Antares hides behind the Moon in this occultation sequence from June 24, 2005. (12-inch Meade LX200 Schmidt-Cassegrain Telescope, Meade LPI Imager, 2:45 A.M.–2:47 A.M. CDT) MILT GOSNEY



THIS DIAGRAM COMPARES the height of this summer's Full Moon with 2001 and 1996's. This year's major lunar standstill results in the summer Full Moon rising at its lowest point and the winter Full Moon rising to its highest point in the sky. *ASTRONOMY*: ROEN KELLY

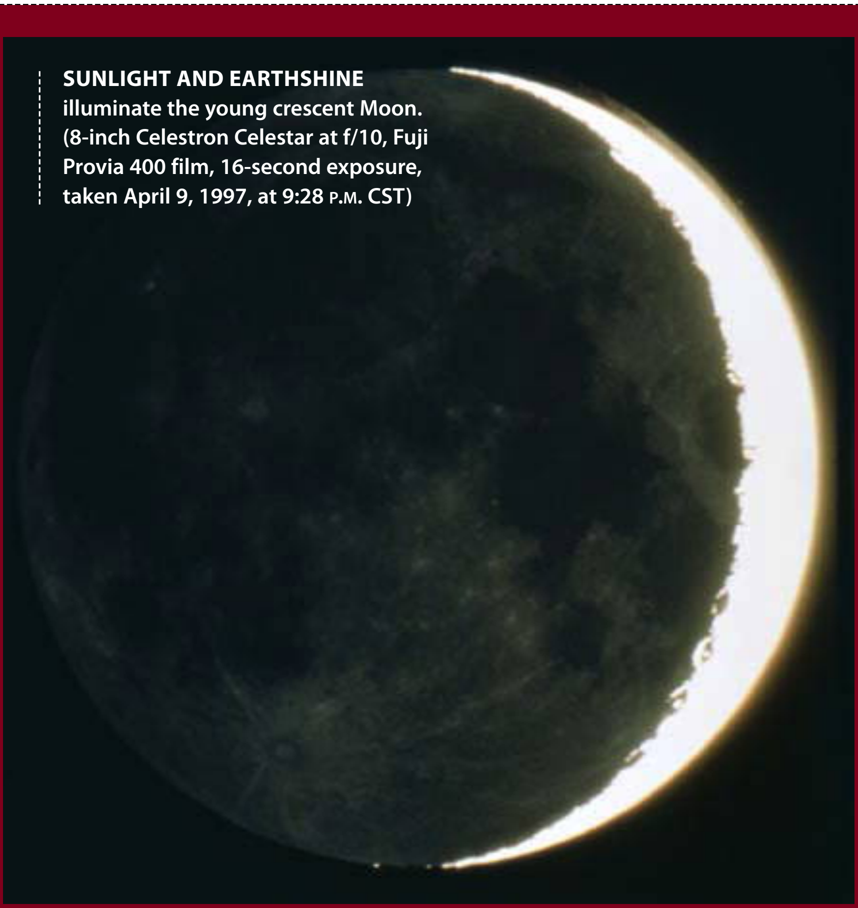
OBSERVING THE MOON WITH *ASTRONOMY*

In the November 2005 issue, Robert Burnham's "Shoot the Moon" provided tips on taking high-resolution lunar photos successfully.

Robert Burnham's Moon Observer's Notebook series includes such articles as:

- "Sail a hidden sea" (May 2005)
- "Rambling in the lunar Alps" (November 2004)
- "Touchdown at Tranquillity" (July 2004)
- "Lunar Apennines" (January 2004)
- "The Straight Wall" (October 2003)

To order these issues, call 800.533.6644 or go to **Astronomy.com**.



SUNLIGHT AND EARTHSHINE illuminate the young crescent Moon. (8-inch Celestron Celestar at f/10, Fuji Provia 400 film, 16-second exposure, taken April 9, 1997, at 9:28 P.M. CST)

JEFF FOLKOWSKI

SIGHTING A YOUNG MOON

During the 24-hour period after a New Moon, try to spot the young crescent Moon shortly after sunset. Many factors affect the chances of seeing the youngest Moon. The best conditions for observing a young Moon in the Northern Hemisphere occur in March and April. The ecliptic then sits at a steep angle to the western horizon. At this time, our satellite rises high above the horizon faster than at times when the ecliptic rests closer to the horizon.

The 1-day-old Moon stands 13° from the Sun, and a 14.5-hour Moon is 7.5° from the Sun. If the Moon stands higher above the horizon, less of Earth's atmosphere blocks the Moon's light. Under bright sky conditions, you can spot the young Moon through binoculars. Many amateur astronomers enjoy competing to see the earliest young Moon. On May 27, it stands 2.8° to the right of Mercury — a helpful signpost. In the Central time zone, the Moon is 0.9-day old and stands 10.5° east of the Sun. — *M. R.*

The Moon makes a full cycle around Earth each month and follows the approximate track across the sky the Sun takes a year to complete. Consequently, we see the range of moonrise/set points within a month that the Sun takes a year to perform, except the Moon wanders farther north and south on the east/west horizon than the Sun.

If the Moon's ascending node — where the Moon's orbit crosses the ecliptic heading north — occurs near the spring equinox (also the location of the Sun in March), as occurs in 2006, then the Moon will approach its northernmost point 90° later in its orbit, which places it in Gemini. The March 29 total solar eclipse confirms the nodal crossing at New Moon.

This wandering leads to the Moon rising farther north of the sunrise and sunset points, and also farther south than the Sun's typical sunrise/set points in winter.

It takes the lunar nodes 18.6 years to make one full rotation around Earth. A minor lunar standstill, when the Moon's rise and set points' wandering is at a minimum, occurs in the middle of this 18.6-year period. The next minor standstill occurs in October 2015. We won't see another major standstill until April 2025.

During a major lunar standstill, the Moon's path takes it in front of the star-studded cluster of the Pleiades (M45) — a nice example of this occurs the evening of April 1 (see the finder chart on page 58). Dozens of stars stand in the path of the Moon's occulting disk, so observing this scene turns into a 100-yard dash.

Some regions of Earth get to see the Moon's limb occult — pass in front of — one star after another, sometimes within a minute of each other. These times are great for beginners to get their first views of occultations, because so many happen in succession. A range of bright and faint stars makes these events fun to observe through any size scope.

The best upcoming views of M45 occultations visible from the United States occur July 20 (morning), August 16 (morning), September 9 (evening), and December 3 (evening).

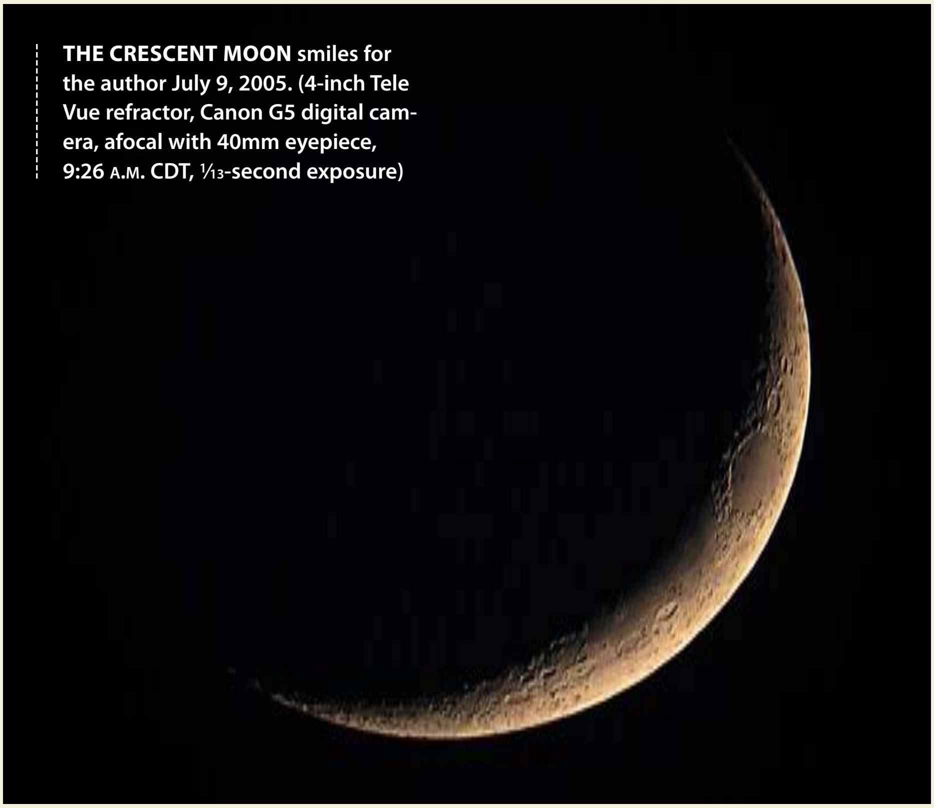
Four 1st-magnitude stars along the ecliptic will be occulted also: Aldebaran, Regulus, Spica, and Antares. Observers on the East Coast will see Spica disappear behind the Moon during the early evening of May 11. In 2007, Regulus and Antares undergo a series of these events.

DIGITAL IMAGING

Digital cameras make imaging the Moon easier than ever before. Because they let you check image quality immediately, take a lot of images and sort out the bad ones.

You also can attach a webcam to your scope. Recording video for later viewing is great fun and gives the whole family a chance to view through your scope. Image-processing freeware such as *Registax* and *Astrostack* glean high-resolution quality from your video images.

During one night of near perfect seeing in September 2004, I took 30 images of the gibbous Moon through my C-11 with a Canon G5 5-megapixel digital camera. I repeated each shot four times and selected the best ones to compile into a huge montage. The variation in detail recorded in four sequential images surprised me. Typically, only one of them is usable. Even under great seeing conditions, however, minor changes in atmospheric seeing blur fine details. — *M. R.*



THE CRESCENT MOON smiles for the author July 9, 2005. (4-inch Tele Vue refractor, Canon G5 digital camera, afocal with 40mm eyepiece, 9:26 A.M. CDT, 1⁄13-second exposure)

MARTIN RATCLIFFE

LIBRATION FEATURES

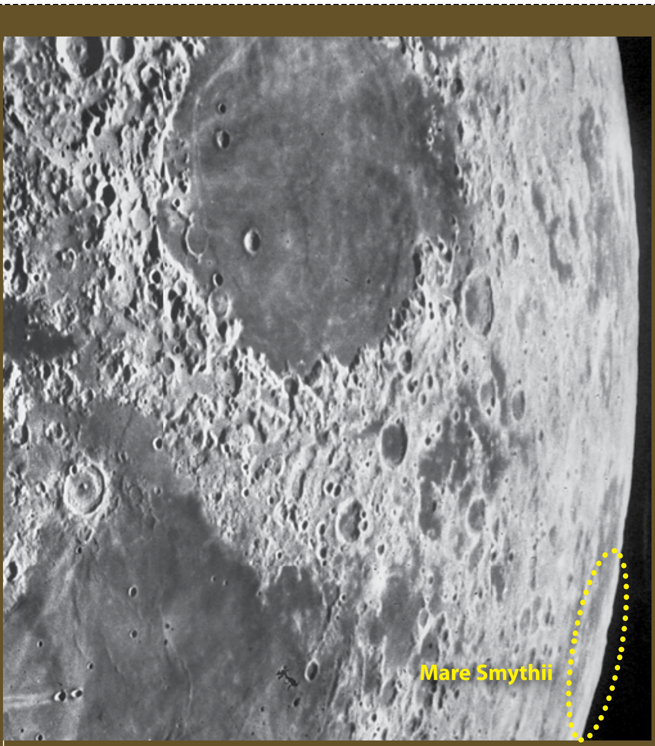
Due to the Moon's elliptical orbit, we can view slightly more than 50 percent of its surface during a month. The Moon rotates at an almost constant rate, so when it moves faster along its orbit around perigee (when it is closest to Earth), we get a sneak peek around its eastern limb. At its slowest orbital velocity, around aphelion (when the Moon is farthest from the Sun), the western limb swings more into view. This effect is known as libration. During the course of a few orbits, we can see almost 59 percent of the Moon, but only 50 percent on each night.

There's also north and south libration because the Moon's orbit wanders north and south of our orbital plane. When the Moon lies north of the ecliptic, we see farther around the southern polar region. Many rarely seen features then rotate into view.

Look for times of extreme libration angles for certain features, such as Mare Marginis and Mare Smythii on the eastern limb, Mare Humboldtianum near the northeastern limb, and Mare Orientale on the western limb. How far Mare Crisium lies from the eastern limb helps you determine current libration conditions.

The Moon offers something new to an observer most clear nights — except around New Moon. The wide-ranging lighting variations rarely produce the same effects. Each crater takes on a new appearance each time you look.

When the next major lunar standstill occurs in 2025, gas could be $10 a gallon, stamps won't exist, and Bart Simpson will celebrate his tenth birthday for the 35th time. And who knows, maybe by then people will be living on the Moon looking back at Earth. — *M. R.*



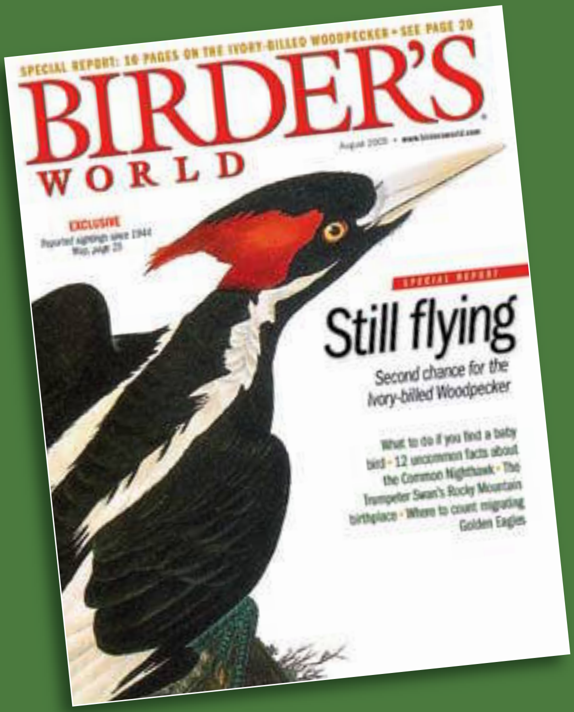
FROM CONSOLIDATED *LUNAR ATLAS* (LPL/UA)

FROM THE SHADOWS, rarely seen features, such as Mare Smythii, emerge because of libration.

Martin Ratcliffe *is a contributing editor of* Astronomy *and coauthors "The sky this month" with Alister Ling.*

ONLINE EXTRA Learn the importance of sketching your lunar observations at www.astronomy.com/toc.

Get closer to birds!


SPECIAL REPORT: 10 PAGES ON THE IVORY-BILLED WOODPECKER • SEE PAGE 20
BIRDER'S WORLD
August 2005 • www.birdersworld.com
EXCLUSIVE
Reported sightings since 1944
Map, page 29
SPECIAL REPORT
Still flying
Second chance for the Ivory-billed Woodpecker
What to do if you find a baby bird • 12 uncommon facts about the Common Nighthawk • The Trumpeter Swan's Rocky Mountain birthplace • Where to count migrating Golden Eagles

With *Birder's World* magazine, you'll see birds closer than you've ever seen them before. Every issue brings you the greatest bird photography in the world, techniques for attracting more birds to your backyard, identification tips, conservation news, information on the best places to see birds when you travel, and much more.

FREE GIFT

when you order!

Welcome to Birdwatching
This 16-page booklet includes tips on bird identification, buying binoculars, and much more.

Welcome to Birdwatching

U.S. Fish and Wildlife Service

Visit us on the web at
www.birdersworld.com

05X1276

A64AB

To subscribe, fill out and mail the attached card, or call 1-800-533-6644

From film to digital imaging, this Chilean amateur astronomer does it all. /// STORY AND IMAGES BY DANIEL VERSCHATSE

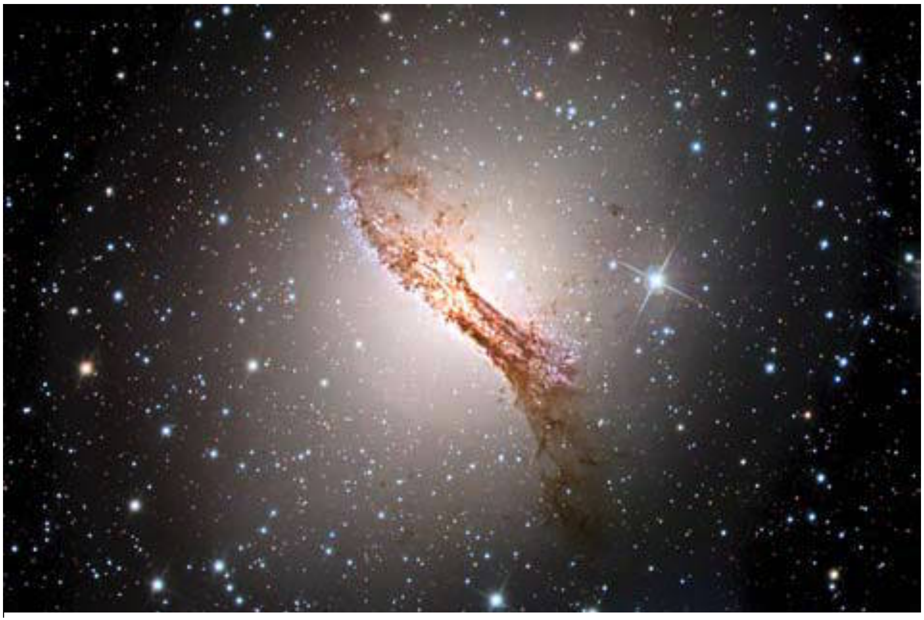
Eye on the southern sky

Astroimaging in Chile is for me what the Alps are for downhill skiers — the perfect place. On the one hand, sky conditions here are fabulous, far better than anything I have seen before. On the other hand, I feel alone because the country has remarkably little amateur astrophotography activity compared to the quality of its night sky. I am one of the few individuals who operate a private observatory with a CCD camera here.

It's an exciting time to be an amateur astrophotographer. Never before has there been such a wide and diverse offering of high-quality imaging instruments, mounts, and image-processing software. The amateur deep-sky images that adorn *Astronomy* each month impressively demonstrate the imaging power of CCD cameras.

Today's successful astrophotographers must have better-than-average knowledge of optics, mechanics, electronics, computer technology, image processing, and astronomy. A bit of meteorology, foreign language skills, and artistic layout don't hurt either.

During the process of creating a celestial image, my personal goal is to convey both the thrill I feel and the object's beauty to the uninitiated observer and the experienced amateur. This requires constant attention to detail: optical quality, drive smoothness and capacity, focusing, framing the object, exposure times, site selection, calibration techniques, image processing … the list goes on and on.



DRAMATIC DUST LANES run across peculiar galaxy Centaurus A (NGC 5128). Its red stars and round shape characterize a giant elliptical galaxy, a type usually low in dust. Centaurus A also contains lots of young blue stars and strongly emits radio wavelengths.

However, that hard-to-reach super shot happens only when everything comes together. And here we start hitting limits: detailed deep-sky imaging requires large-aperture and medium- or long-focal-length instruments. Taking good optics and mechanics as a given, these telescopes are often "seeing limited" — the difference between a good and an excellent image is due entirely to the air stability. Site selection, therefore, is critical. A big scope makes sense only under a stable sky.

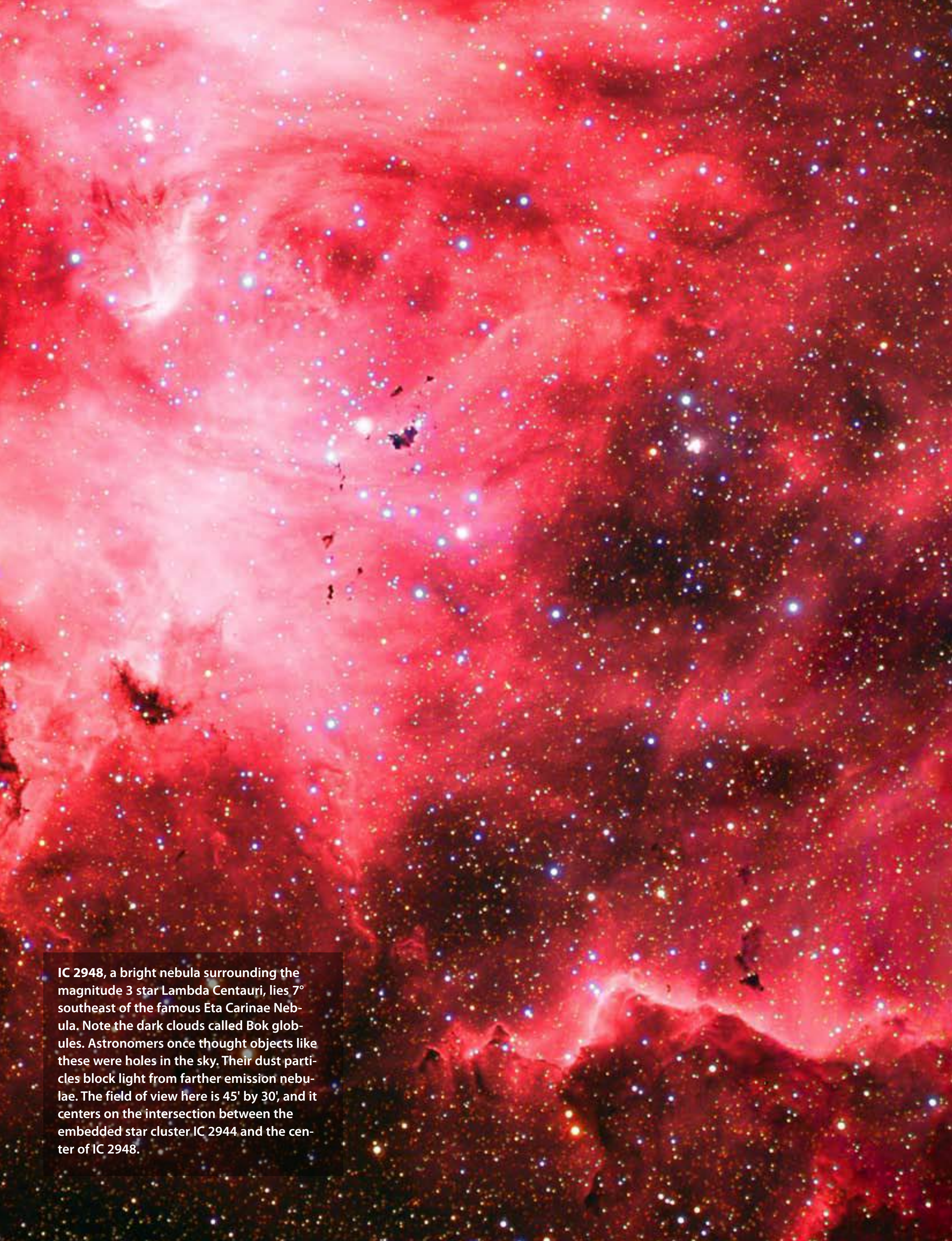
Since 2002, I have been on a quest for the ideal site. It may sound odd, but, in Chile, high-quality sites are rare. The country's northern regions have scores of excellent sites with sub-arcsecond seeing, but they require an enormous investment in infrastructure to reach them and make them livable. And while the Atacama Desert may be the driest place on Earth, it's not as empty as it appears.

Mining abounds, often open-pit with little regard for light-pollution regulations that went into effect last year. Other factors also come into play: zoning laws, mineral rights, prohibitively large properties, and local politics, to name a few.

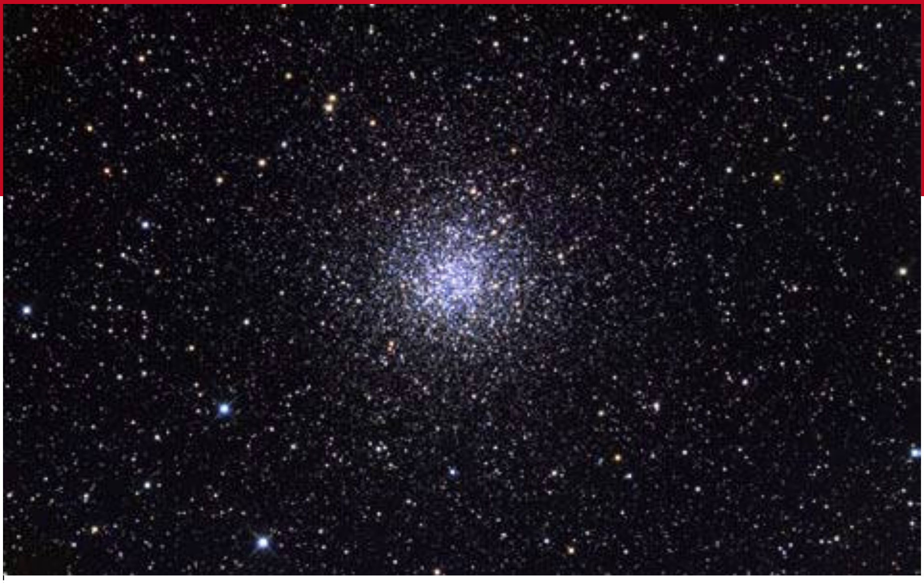
My quest may have come to an end, though: I've located a site that has both good seeing and infrastructure, is easily reachable, and, most importantly, offers a perfect setting for my interest in teaching astrophotography to beginning observers.

I'm turning ambitious plans into blueprints, and, as I do, I realize the aperture fever I experienced as a youth has been slumbering. What is it about astrophotography that makes us go through all the hardships and expense? If you're like me, it's not just a hobby, it's your passion. A

Daniel Verschatse *is a dedicated amateur astronomer who observes and images under Chile's clear, dark skies.*

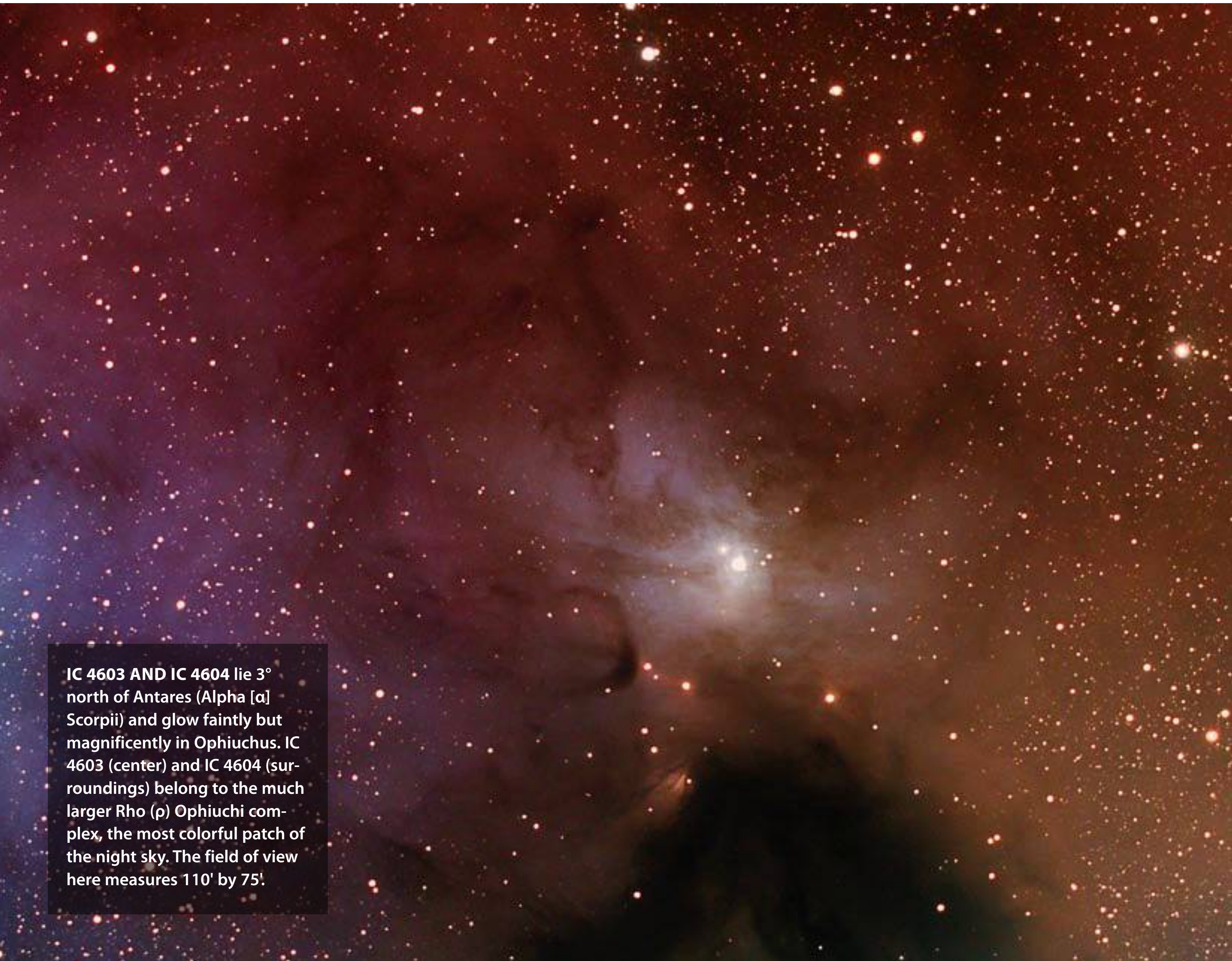


IC 2948, a bright nebula surrounding the magnitude 3 star Lambda Centauri, lies 7° southeast of the famous Eta Carinae Nebula. Note the dark clouds called Bok globules. Astronomers once thought objects like these were holes in the sky. Their dust particles block light from farther emission nebulae. The field of view here is 45' by 30', and it centers on the intersection between the embedded star cluster IC 2944 and the center of IC 2948.

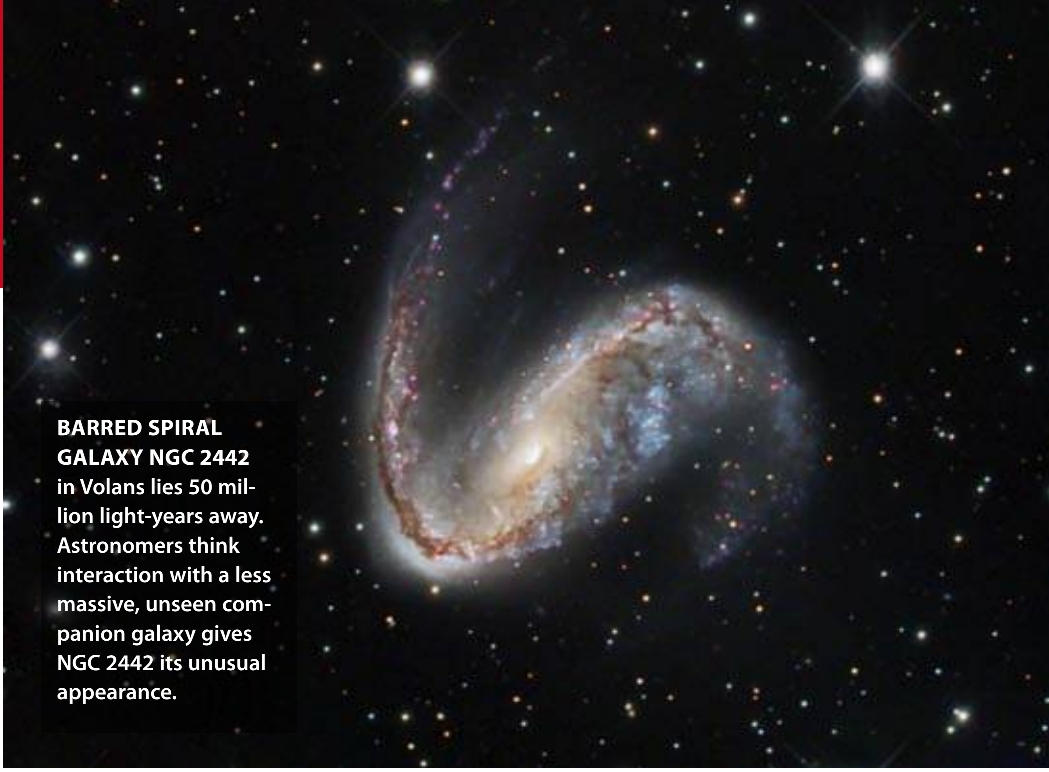


GLOBULAR CLUSTER NGC 3201 lies 5.7° northwest of Mu (μ) Velorum. At magnitude 6.9, NGC 3201 ranks as one of the sky's 25 brightest globulars. A 6-inch or larger telescope provides a great view of this object visually. This image's field of view measures 37' by 25'.

BARNARD'S GALAXY (NGC 6822) is a dwarf irregular galaxy located approximately 1.6 million light-years from Earth. It's part of the Local Group, which contains about 3 dozen galaxies including our Milky Way. Edward Emerson Barnard discovered NGC 6822 in 1884. Reddish regions denote large emission nebulae, and a bluish arm of young stars extends toward the upper right.



IC 4603 AND IC 4604 lie 3° north of Antares (Alpha [α] Scorpii) and glow faintly but magnificently in Ophiuchus. IC 4603 (center) and IC 4604 (surroundings) belong to the much larger Rho (ρ) Ophiuchi complex, the most colorful patch of the night sky. The field of view here measures 110' by 75'.



BARRED SPIRAL GALAXY NGC 2442 in Volans lies 50 million light-years away. Astronomers think interaction with a less massive, unseen companion galaxy gives NGC 2442 its unusual appearance.

MY IMAGING JOURNEY

Dedicated amateur astronomers create celestial images from a combination of long nights, extended computer sessions, and capital investment. But the best images take more than equipment and clear nights — they require passion.

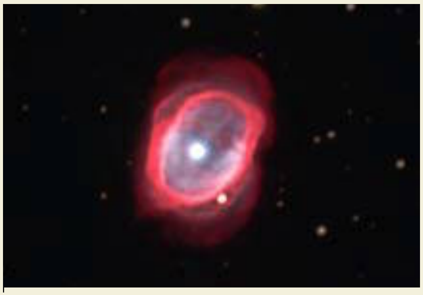
When I talk to fellow amateur astronomers, it seems most — if not all — remember clearly what event pushed them over the point of no return — the moment the astronomy bug infected them.

It may seem strange, but I have no such pinpoint recollection. As a young boy, science in general interested me. I remember devouring a series of illustrated science books in my native Flanders (Belgium), called *Jongens en Wetenschap* (Boys and Science). These may have planted a seed.

Perhaps it was the small 2-inch no-name spotting scope with less-than-average optics that got me started. From the attic window, I observed sparrows and blackbirds. I remember my surprise when I turned it toward the Moon.

When I was about 14, I decided I needed a "real" scope and went through the obligatory grinding and polishing of a 6-inch (15-centimeter) mirror. The project resulted in a fair telescope, but I was frustrated because I had no means to build a mount for it.

The next step was logical: I needed a telescope on an equatorial mount. Not many commercial instruments were available, so I quickly settled on a Polarex (Unitron) achromatic refractor. Prices were astronomical for a working-class high-school kid like me. But, even so, my first case of aperture fever soon elevated my sights from the original 2.4-inch (60 millimeter), over the 3-inch (75mm), and toward the 4-inch (100mm) f/15 achromat.



THE EIGHT-BURST NEBULA (NGC 3132) shines at magnitude 8 but measures only 48" across. Outbursts from its central star created the intricate structure, hence the name Eight-Burst Nebula. NGC 3132 is sometimes called the Southern Ring Nebula.

What followed was 3 years of working odd jobs to save enough money. During this time, I also began to think about photographing objects, so I expanded the setup with a 3-inch (75mm) guide scope.

The moment the telescope arrived, I set it up on a permanent pier. This marked the take-off point for an intense and exciting period of astronomical activity that lasted through my college years.

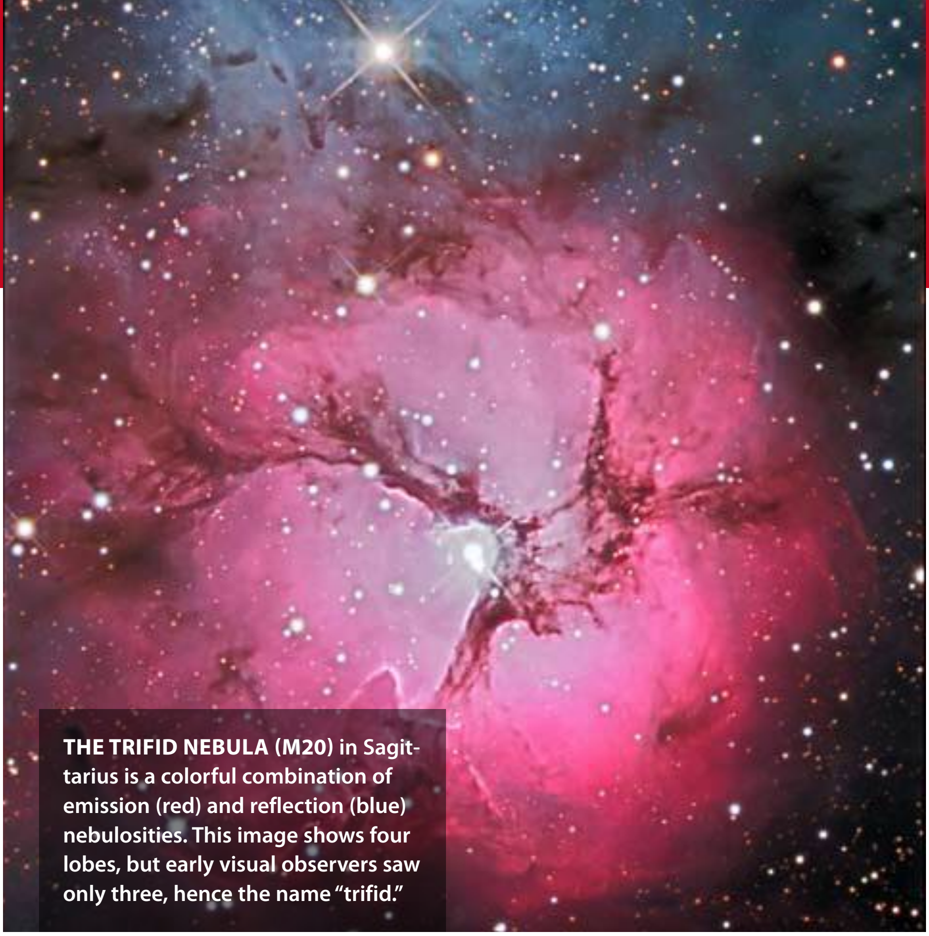
Astrophotography soon became my major focus, and, together with a neighborhood friend, I embarked on a journey that — I recognize now — formed the basis of my later astrophotography. We experimented with everything we could get our hands on: glass photographic plates, high-contrast film (for the Sun and Moon), Kodak Tri-X black-and-white, and Agfa color slide film for deep-sky objects. We had our own darkroom where we experimented with all available developers in our attempt to produce the best photos possible.

In the field, we struggled with polar alignment and the elements. After a few years, we were running strong and had some published results to show for it: a transit of Mercury, a high-resolution image of Saturn, and a series of posters of Comet C/1969 Y1 (Bennett).

After college came an astronomical hiatus. In the mid-1990s, I found the time and dedication to return to astrophotography.

The crystallizing factor was the appearance of high-quality apochromatic refractors. Their performance so impressed me that, a few days after receiving a 4-inch telescope, I placed an order for a 6-inch model. These instruments, together with CCD cameras, paved my way into modern imaging. In 1999, I moved to Chile.

I soon found a place for my first permanent observatory, far enough from the metropolitan Santiago light dome but close enough to reach by a 2-hour drive. — *D. V.*

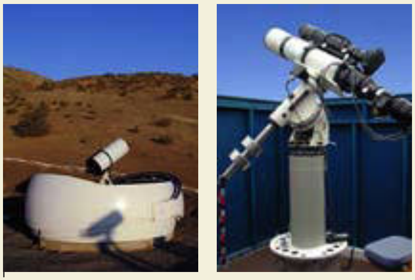


THE TRIFID NEBULA (M20) in Sagittarius is a colorful combination of emission (red) and reflection (blue) nebulosities. This image shows four lobes, but early visual observers saw only three, hence the name "trifid."

ANTILHUE OBSERVATORY

I observe and image from a place I've named Antilhue Observatory. Antilhue is a word in the language of the Mapuche, the indigenous people of central-southern Chile. Antilhue combines the words antu (Sun) and hue (place, site), meaning a sunlit place, or a sunny site.

Antilhue Observatory sits about 60 miles (100 kilometers) north of Santiago de Chile, in a valley in the Andes mountain range. The altitude is 4,500 feet (1,500 meters). Hills and mountains surround the site, resulting in a 360° horizon at 10° to 15° elevation.



THE NEW 14.5-INCH Ritchey-Chrétien reflector sits in its clamshell dome (left). The main scopes, 6.1-inch and 4-inch Astro-Physics refractors ride atop an Astro-Physics AP900GTO mount.

This location has dry, hot summers (during Northern Hemisphere winters) with generally clear nights from October through March. Winters are wet and mostly cloudy, with frequent intervals of transparency, usually after a cold front has moved through.

I planned the observatory as a 10' by 10' (3m by 3m) roll-off roof design. I realized, however, that a "warm room" for storage and sleeping would be a welcome addition, so I utilized the empty area underneath the rolled-off roof. The warm room has a table, dual bunk beds, and an operator desk.

Underneath the desk is a 300 ampere-hour, 12-volt DC battery bank that powers everything. Roof-mounted photovoltaic panels keep the batteries charged.

Telescopes

The main telescope is a 6.1-inch f/7.2 Astro-Physics 155EDFS apochromatic refractor. The second telescope is its smaller brother, a 4-inch f/6 Astro-Physics Traveler.

In August 2003, I installed a 14.5-inch RCOS Ritchey-Chrétien telescope. This instrument features dual f/9 and f/15 optics.

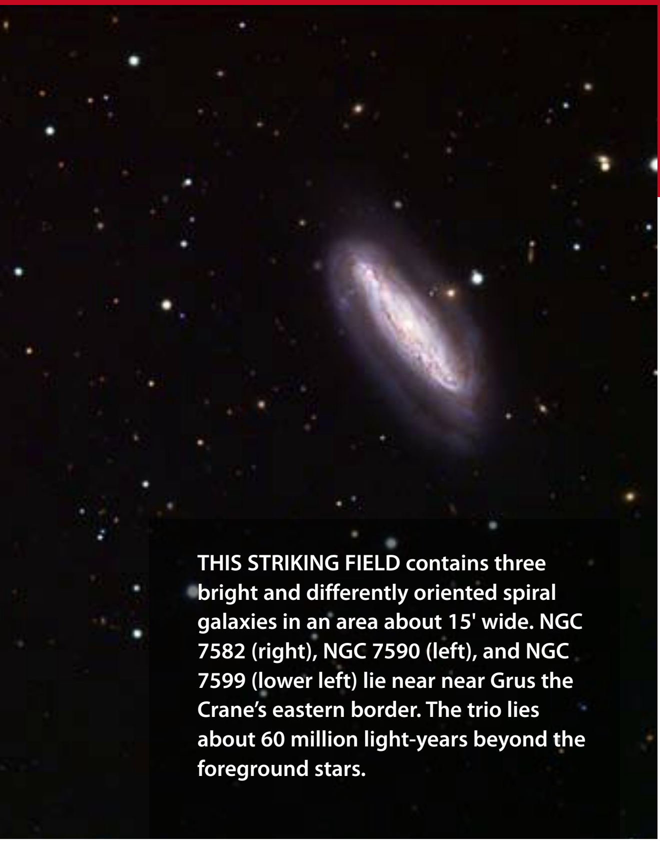
THE OBSERVATORY sits at an altitude of 4,500 feet (1,500 meters) in the foothills of the Andes Mountains.

Mounts

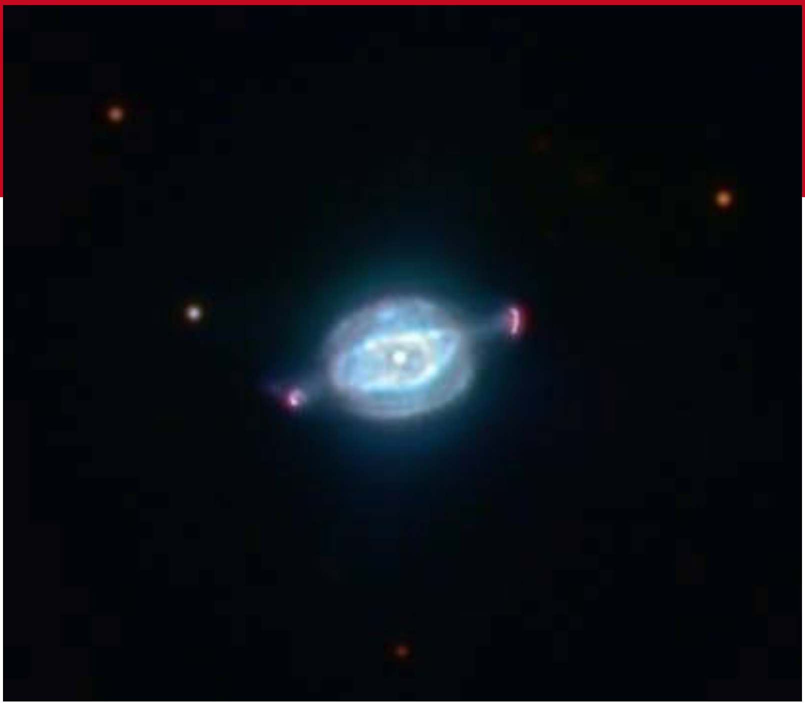
A 14" by 14" (35cm by 35cm) concrete pier on a 1-cubic-meter foundation protrudes through the observatory floor and tapers to a 10"-diameter (25cm) cylindrical support for the telescope's mount.

An Astro-Physics AP900GTO mount carries both refractors with ease and achieves an impressive sub-arcsecond guiding performance. A dovetail bar allows me to attach the Traveler to the main refractor. This setup permits easy balancing because I can move the smaller scope back and forth. A smaller dovetail bar on top of the Traveler can piggyback a camera or other accessories.

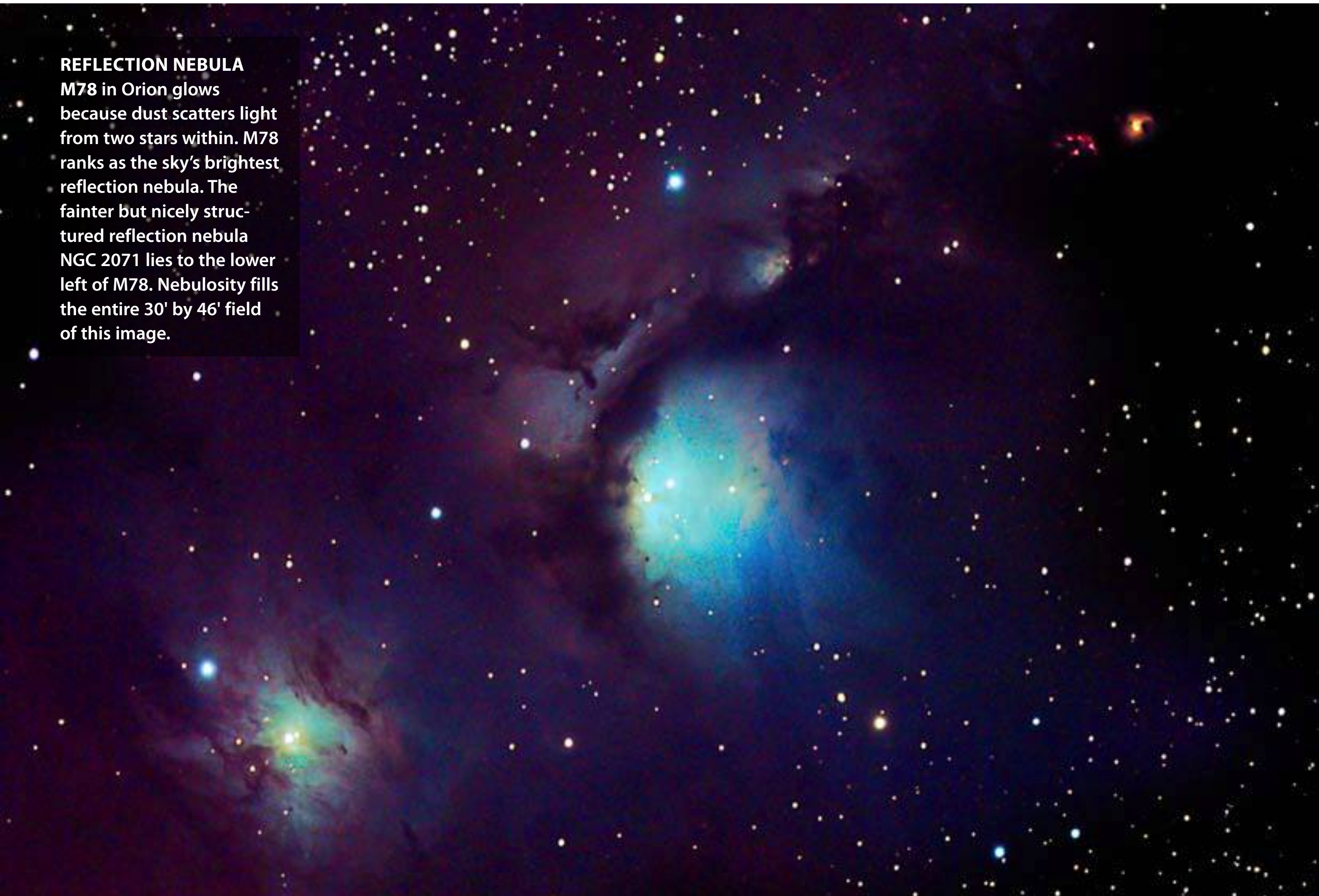
I mounted the 14.5-inch telescope on an Astro-Physics AP1200GTO mount and housed it in a separate 12-foot clamshell dome by Astro-Haven. — *D. V.*



THIS STRIKING FIELD contains three bright and differently oriented spiral galaxies in an area about 15' wide. NGC 7582 (right), NGC 7590 (left), and NGC 7599 (lower left) lie near near Grus the Crane's eastern border. The trio lies about 60 million light-years beyond the foreground stars.



THE SATURN NEBULA (NGC 7009) in Aquarius shows an intricate structure that includes two short equatorial rays, or ansae, with reddish, almost stellar, condensations at their ends. NGC 7009 shines at 8th magnitude and has an apparent diameter of 25". The field of view here is about 8' by 5'.



REFLECTION NEBULA M78 in Orion glows because dust scatters light from two stars within. M78 ranks as the sky's brightest reflection nebula. The fainter but nicely structured reflection nebula NGC 2071 lies to the lower left of M78. Nebulosity fills the entire 30' by 46' field of this image.

DISCOVER

Kitt Peak

National Observatory

Tucson, AZ

Public Programs for Amateur Astronomers

- CCD Workshops
- Digital camera imaging
- CCD Imaging with our expert guides
- Astrophotography
- or just observe

520-318-8726

www.noao.edu

ATOMIC TIME

1010 Jorie Blvd. #332
Oak Brook, Il 60523
1-800-985-8463
www.atomictime.com

ADWA101 - $49.95

14" LaCrosse Black Wall
WT-3143A $26.95

This wall clock is great for an office, school, or home. It has a professional look, along with professional reliability. Features easy time zone buttons, just set the zone and go! Runs on 1 AA battery and has a safe plastic lens.

Digital Chronograph Watch
ADWA101 $49.95

Our feature packed Chrono-Alarm watch is now available for under $50! It has date and time alarms, stopwatch backlight, UTC time, and much more!

WT-3143A - $26.95

WS-8248 - $64.95

LaCrosse Digital Alarm
WS-8248U-A $64.95

This deluxe wall/desk clock features 4" tall easy to read digits. It also shows temperature, humidity, moon phase, month, day, and date. Also included is a remote thermometer for reading the outside temperature on the main unit. approx. 12" x 12" x 1.5"

1-800-985-8463
www.atomictime.com
Quantity discounts available!

WS-9412U - $19.95

LaCrosse WS-9412U Clock $19.95

This digital wall / desk clock is great for travel or to fit in a small space. Shows indoor temp, day, and date along with 12/24 hr time. apx 6"x 6"x 1"

Tell time by the U.S. Atomic Clock -The official U.S. time that governs ship movements, radio stations, space flights, and warplanes. With small radio receivers hidden inside our timepieces, they automatically synchronize to the U.S. Atomic Clock (which measures each second of time as 9,192,631,770 vibrations of a cesium 133 atom in a vacuum) and give time which is accurate to approx. 1 second every million years. Our timepieces even account automatically for daylight saving time, leap years, and leap seconds. $7.95 Shipping & Handling via UPS. (Rush available at additional cost) Call M-F 9-5 CST for our free catalog.

SAVE BIG MONEY

Call us Toll-Free for a price quote and recommendations on your next purchase.

Found a lower price?
Call ... we'll try to beat it!

- Telescopes
- Telescope Accessories
- Digital Cameras - Automatic
- Digital Cameras - SLR
- Camera Lenses & Flashes

SHUTAN
camera & video
866-621-6363
Vernon Hills, Illinois
www.shutan.com

JOIN *ASTRONOMY* MAGAZINE'S

Andean Astronomy Winter Solstice Tour

Astronomy magazine & Astronomical Tours

PRESENT

JUNE 22 — JULY 2, 2006

WITH SPECIAL GUEST: Laura Baird, *Astronomy* Copy Editor

ENIGMATIC ASTRONOMY OF THE INCAS AT MACHU PICCHU AND BOLIVIAN HIGH PLATEAU

11 days from $2,450 per person

- Machu Picchu
- Front-row seats to the Incan Solstice Ceremony
- Guided tours of Incan ruins in Cuzco
- Floating "uros" islands
- Isla del Sol and Isle of the Moon
- Tiwanacu Sun Temple
- PLUS: High-altitude, deep-sky nighttime observing with 10-inch and 22-inch telescopes

CONTACT JEN WINTER
AT ASTRONOMICAL TOURS:
Call: 660-747-9458
or E-mail: jen@astronomicaltours.net
Web site: www.tourwithastronomy.com (CST# 206814-40)

Astronomy magazine

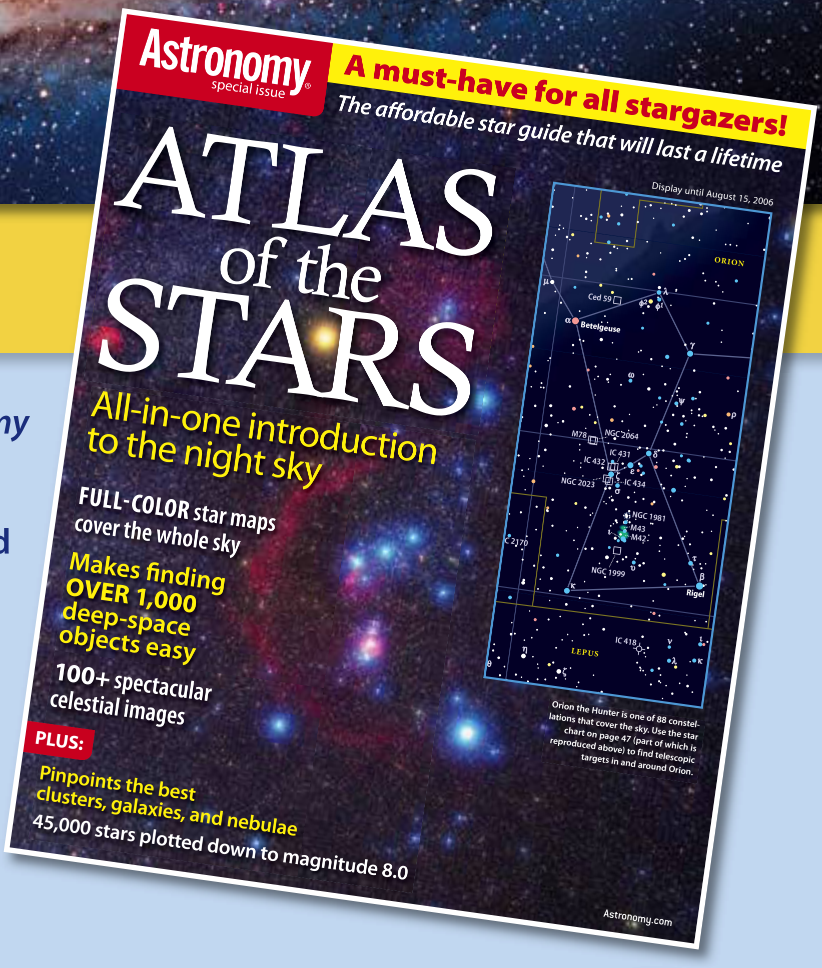
Mention **MachAsy06** when booking your tour to be entered in the *Astronomy* magazine drawing to win a Tele Vue-60 Telescope, Vixen Porta Mount, plus accessories.

Vixen
TeleVue

05X1406RH

Reach for your *Atlas of the Stars!*

TONY HALLAS



Astronomy special issue

A must-have for all stargazers!

The affordable star guide that will last a lifetime

Display until August 15, 2006

ATLAS of the STARS

All-in-one introduction to the night sky

FULL-COLOR star maps cover the whole sky

Makes finding **OVER 1,000** deep-space objects easy

100+ spectacular celestial images

PLUS:

Pinpoints the best clusters, galaxies, and nebulae

45,000 stars plotted down to magnitude 8.0

Orion the Hunter is one of 88 constellations that cover the sky. Use the star chart on page 47 (part of which is reproduced above) to find telescopic targets in and around Orion.

Astronomy.com

Reserve your copy today and SAVE!

This all-new Special Issue from *Astronomy* magazine is an all-in-one introduction to the night sky for beginners – and a timeless go-to reference for experienced astronomers who want to get more from the night sky!

- A great reference in the field or at your desk
- Observing tips and how to get the most out of a star party
- A comprehensive look at the sky's brightest and most beautiful objects
- Plus **MUCH MORE!**

Don't miss out! Order your copy TODAY!

Act now and SAVE!

Simply fill out and mail the card in this issue today!

Order online at: www.astronomy.com

Or call: 1-800-533-6644

(Mon-Fri, 8:30am – 5:00pm Central Time. Outside the U.S. and Canada, call 262-796-8776, x661.)

Astronomy magazine

05X1267

A64AA2

Starmaster's new go-anywhere scope is a quick-change artist with two mounting options. /// BY VIC WINTER

Two scopes in one

A new line of Newtonian reflectors

from Starmaster Portable Telescopes — the Versa series — aims at amateur astronomers who want fast setup for visual observing and also imaging capabilities. ☾ When you just want a quick look at the sky, the Versa-8 is ready to go as fast as you can set the Dobsonian base down and place the tube assembly into it. When you want to track or photograph objects, it takes only 5 minutes to add the ring assembly that allows the tube to ride on any German equatorial mount.

The Versa telescope line is available in both 8- and 11-inch models.

The 8-inch Versa, which I tested, is surprisingly light. The tube assembly weighs less than 35 pounds (16 kg) with everything — including the counterweight — attached. The tube measures just under 48 inches (122 cm), so it can rest easily in the backseat of most cars and trucks. With the scope set up as a Dobsonian-mounted reflector, you can observe the stars less than 2 minutes after arriving at your site.

Optional rotating rings allow you to connect the Versa-8's tube to various equatorial mounts. The rings install easily.

The 8-inch, f/5.6 Zambuto mirror sits in a six-point flotation cell with adjustable edge supports. The secondary mirror measures 1.52 inches. All views through this scope were crisp and sharp from edge to edge. During nights when the seeing was good, the Versa-8 gave me exceptional visual and photographic planetary views.

All accessories that come with the Versa-8 are top-notch. The two-speed Feathertouch focuser accommodates both

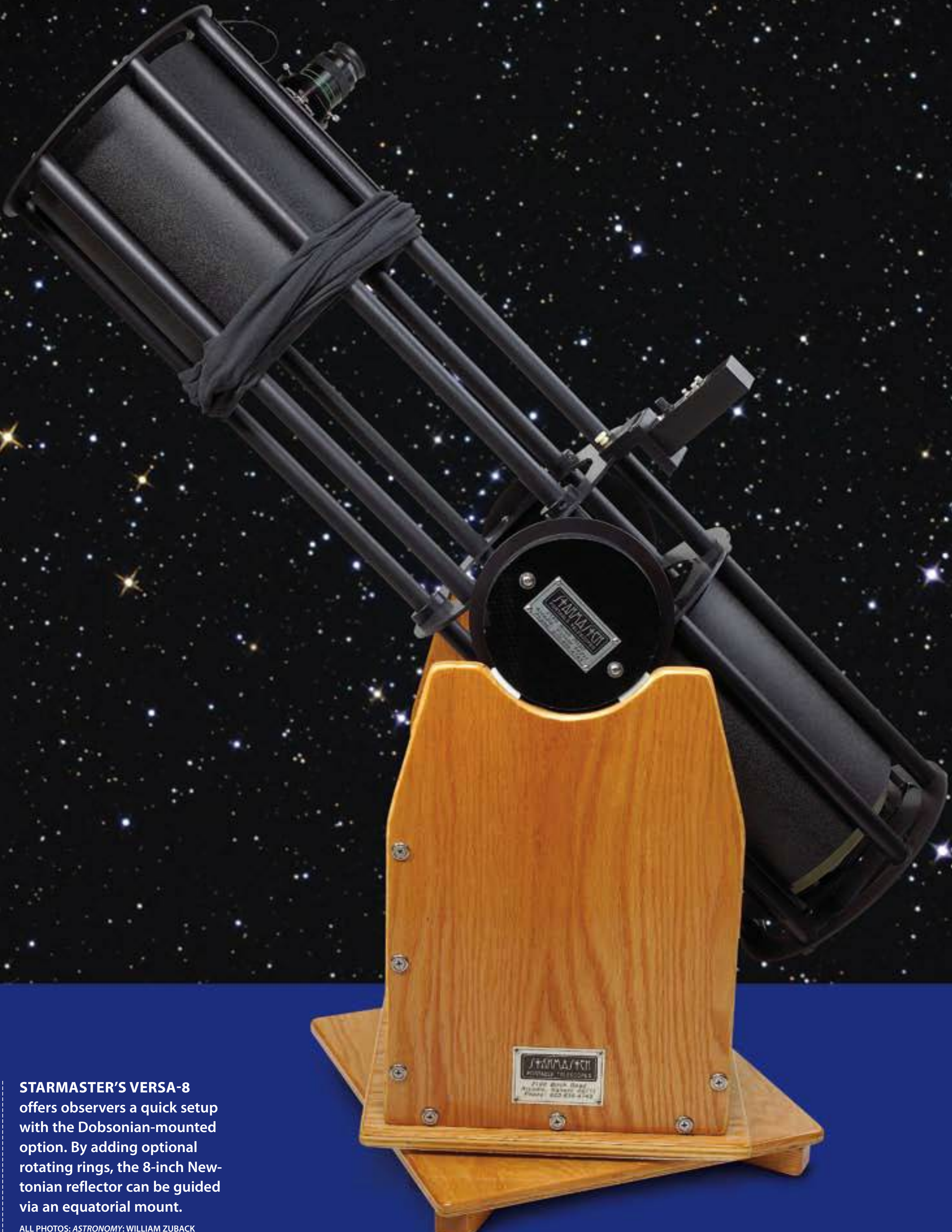
FOR QUICK SETUP, add the optional rocker box. Place the optical-tube assembly in the cradle, and you're ready to observe.

Vic Winter *is a longtime amateur astronomer and imager who, with his wife Jen, operates Astronomical Tours in Warrensburg, Missouri.*

A RIGEL QUIKFINDER attaches to a mount that you can move to any position along the Versa-8's outer ring.

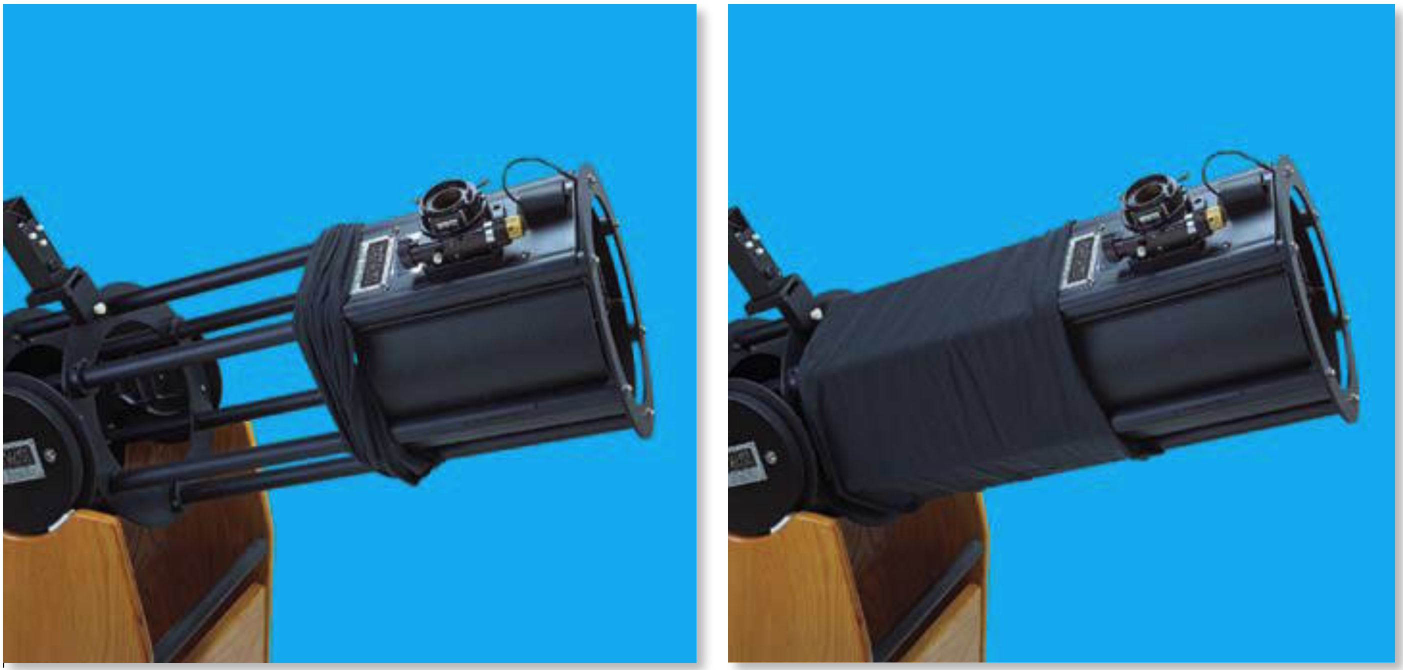
THE SECONDARY-MIRROR assembly contains a built-in dew heater powered by a 9-volt battery.

THE FEATHERTOUCH FOCUSER operates at two speeds. It accommodates both 2" and 1¼" eyepieces (with a supplied adapter).


STARMASTER
PORTABLE TELESCOPES

STARMASTER'S VERSA-8 offers observers a quick setup with the Dobsonian-mounted option. By adding optional rotating rings, the 8-inch Newtonian reflector can be guided via an equatorial mount.

ALL PHOTOS: *ASTRONOMY*: WILLIAM ZUBACK



STARMASTER'S VERSA-8 includes two light shrouds that help you deal with unwanted light because light pollution can be a problem for strut-supported Newtonian reflectors. One shroud envelops the primary mirror. The other shroud, shown above, covers the front of the optical-tube assembly. The left image shows the light shroud in its retracted position. On the right, the flexible shroud is deployed.

/// SPECIFICATIONS

STARMASTER VERSA-8

- 8-inch f/5.6 Newtonian reflector
- 1.52-inch secondary mirror
- Secondary-mirror dew heater
- Two-speed Feathertouch focuser (accommodates both 1¼" and 2" eyepieces)
- Sliding stainless-steel counterweight
- Movable zero-power finder

PRICE:

Optical-tube assembly: $2,895
Rotating rings with dovetail plate: $265
Two-piece travel-truss system: $95
Altitude-azimuth rocker box: $295

CONTACT INFORMATION:

Starmaster Portable Telescopes
2160 Birch Road
Arcadia, KS 66711
[t] 620.638.4743
[w] www.starmastertelescopes.com

2" and 1¼" eyepieces. The built-in secondary mirror's dew heater is handy for nights when water seems to drip off the scope constantly. Two shrouds reduce unwanted light from creeping through the open-truss design and onto the mirrors. You can place a unity-power finder scope anywhere on the end ring — a handy design.

All tube components are anodized aluminum, which provides a lightweight but rigid truss system. You'll need only one tool — a Phillips screwdriver — to assemble or disassemble the entire telescope, including the altitude-azimuth rocker box.

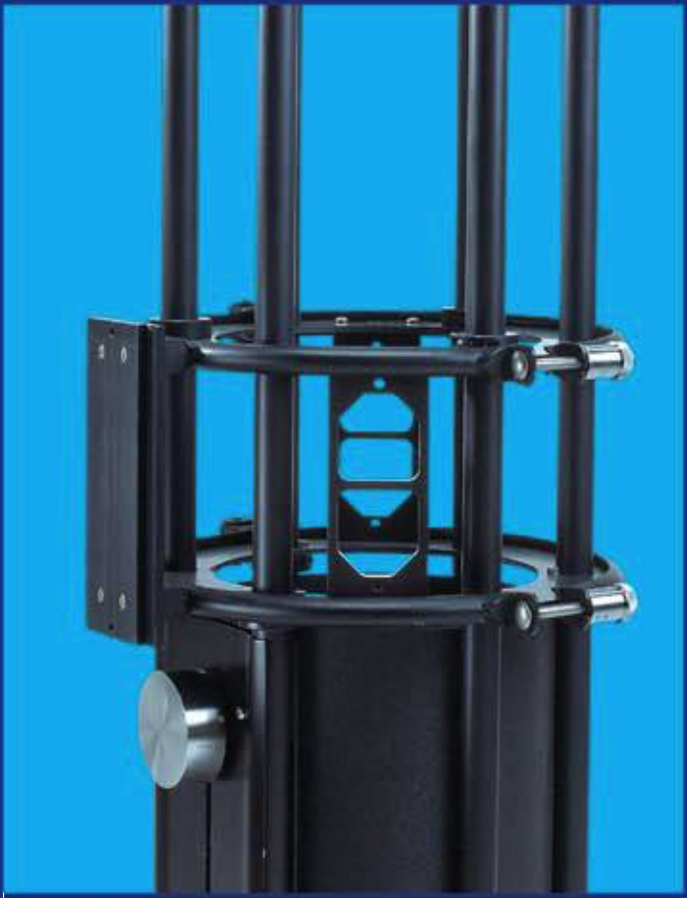
To put the Versa-8 to the ultimate travel test, I took it on a cruise of the Galapagos Islands off the coast of South America and used it to view the April 8, 2005, total solar eclipse. Before leaving, I disassembled the Versa-8, down to the last nut and bolt, and packed everything into a small cardboard box. I carefully covered the mirror with lens paper that wouldn't scratch it, bubble-wrapped it, and placed it in my carry-on luggage. Everything — with the exception of the truss tubes — fits into a Pelican case that meets airline-baggage size limits. I packed the truss tubes in a hard-shell golf-bag travel case I normally use to transport a German equatorial mount.

Views of the night sky from the equator were breathtaking and demonstrated the quality of the Versa-8's optics. (Starmaster's president, Rick Singmaster, tests each telescope under the stars prior to shipping them directly to customers.) The ship's gentle motion moved the target objects in and out of the field of view, but I minimized this problem by using wide-field eyepieces. On the open sea — 1,200 miles (1,930 km) west of the islands where the eclipse occurred — observing was more difficult because the swells rose higher.

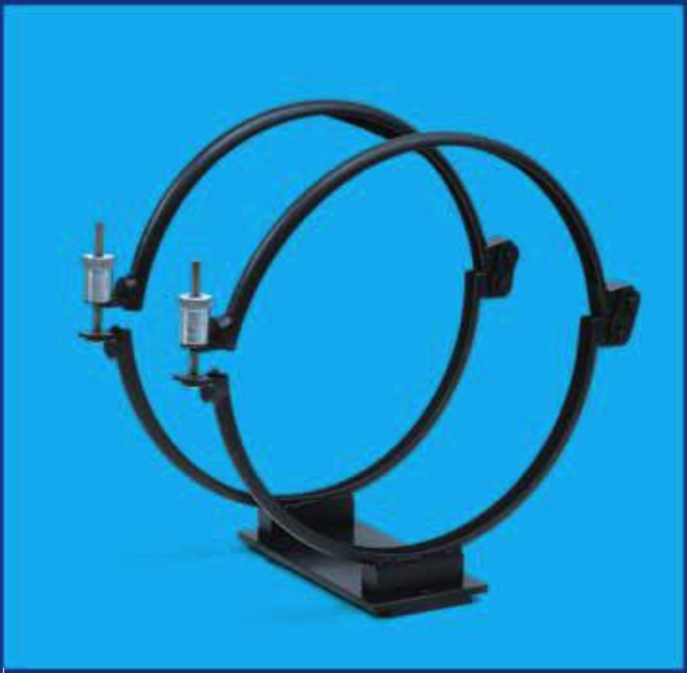
Besides visual observing, I wanted to photograph the eclipse. The adjustable focuser mounting plate came in handy when I attached a large-format camera to the Versa-8. Through a full-aperture solar filter, I found the telescope easy to focus when I aimed it at the Sun. The telescope's smooth motions made keeping the Sun centered in the field of view easy despite the ship's side-to-side motion.

To make traveling with the Versa-8 easier, Starmaster offers an optional set of truss tubes that split into two sections and can fit in your luggage. When assembled, which takes only a few seconds, the truss tubes' rigidity surprised me. You won't have any flexure problems between the primary and secondary mirrors.

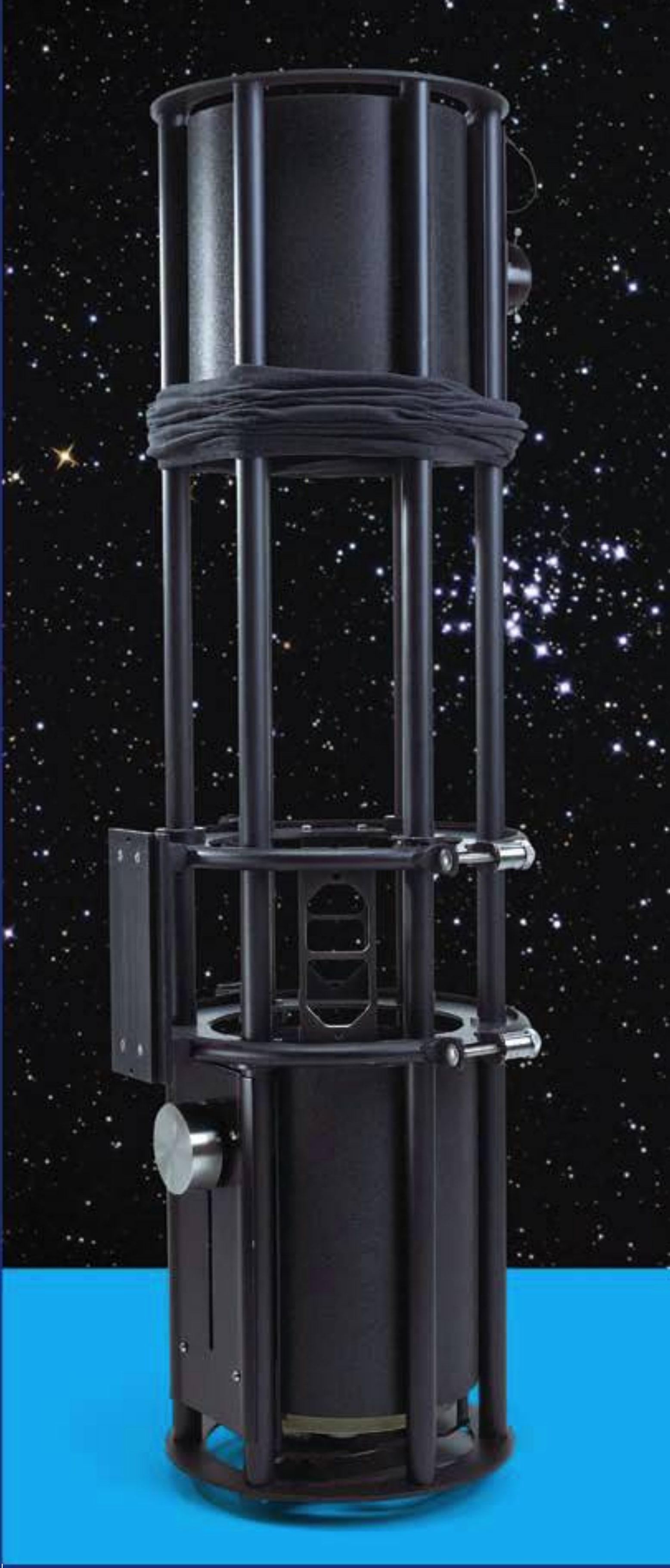
So, opt for the best of both worlds — quick, Dobsonian-mounted observing and equatorially mounted tracking and imaging. If you want this package in one telescope, take a close look at the Versa line.



THE TUBULAR STRUTS support the telescope's optics and accessories. You can order them either as one-piece units or as the travel-system option, where each strut breaks down into two pieces. This allows them to fit into standard luggage.



THE ROTATING RING ASSEMBLY attaches to the central support ring on the Versa-8. This optional accessory allows you to mount the telescope to an equatorial platform. Starmaster Telescopes will machine the dovetail assembly (at bottom) to fit your drive.



THE STAINLESS-STEEL COUNTERWEIGHT slides back and forth, allowing you to use eyepieces or cameras of different weights. Starmaster includes the adjustable counterweight as standard equipment on the Versa-8.

MARS GLOBE 20x

The Relief Globe Company
Boulder Creek, CA

- Mountain heights exaggerated by 20 times
- 18 inches wide
- Made of liquid polymer

Price: $599
[w] www.reliefglobe.com
[t] 831.338.1726

TV-60 IMAGING SYSTEM

Tele Vue Optics, Inc.
Chester, NY

- Digital micrometer focus-position measurement to 0.0001"
- 2-inch mirror diagonal provides a maximum visual field of 7.3°
- Solid dovetail for mounting to Vixen, Losmandy, and other plates

Price: $1,625
[w] www.televue.com
[t] 845.469.4551

SKYSCOUT

Celestron
Torrance, CA

CELESTRON
SkyScout
SkyScout

- Internal GPS automatically tells user 10 night-sky objects visible from her/his location
- USB port allows for updates of the operating software
- SD card slot exists for additional content offerings

Price: $399
[w] www.celestron.com
[t] 310.328.9560

LIGHTBRIDGE TRUSS TUBE DOBSONIAN

Meade Instruments Corporation
Irvine, CA

- Diffraction-limited optics
- 2" Crayford-style machined aluminum focuser with 1-inch adapter and a built-in primary-mirror cooling fan
- 8-inch model is f/6; 10- and 12-inch models are f/5

MEADE
LIGHTBRIDGE

Price: $469–$1,049
[w] www.meade.com
[t] 800.919.4053

BINOCULAR VIEWER FOR TELESCOPES

Orion Telescopes and Binoculars
Watsonville, CA

- Hinged aluminum housing contains multicoated BAK-4 prisms that provide high light transmission
- 1-inch barrel is threaded to accept filters
- Works with all types of telescopes

Price: $199
[w] www.telescope.com
[t] 800.447.1001

TRACKER IMAGING PLATFORM

Taurus Technologies
Woodstown, NJ

- Flip mirror, direct-view focuser, and off-axis guider
- Standard 2" filters can be inserted in the camera adapter
- Camera can be independently rotated 360° to allow image positioning without affecting the guide-star position

Price: $394
[w] www.taurus-tech.com
[t] 856.769.4509

HomeDome/ProDome

PD10 in Russia

- True Rotating Dome
- Easy Assembly
- 6, 10, 15ft. Diameter
- All Fiberglass
- Motors & Automation
- Wide Slot Openings
- Complete Systems Priced from $2790

ROBOFOCUS™
Automated Focus Driver
with temperature compensation
$395

Technical Innovations, Inc.
7851 Cessna Ave.
Gaithersburg, MD 20879
Ph: 301-977-9000 • Fax: 301-977-1106

FREE BROCHURE
www.homedome.com

The ONLY Green Laser Designed Specifically for Astronomy!

- Easily mounts to any telescope
- Can run for hours
- Designed to operate in cool weather
- Computer programmed to 5mW
- 4 models to choose from

Thousands sold—fast delivery & we ship worldwide.

Go to www.LuckyDuck.com or call toll-free **877-388-7362** to order or learn more.

(Shown here with one of several available telescope mounts—beam is simulated)

Jasper *The next generation green laser.*

ScopeBuggy

MAKING VIEWING EASIER

- For use with most tripods, DOBs and piers
- Load tested to 600+ pounds
- Assemble in minutes for use or storage
- Pneumatic inflated 10" tires for soft ride
- Gloss black powder coat paint
- Optional battery equipment tray
- Adjustable rear axle height, 1 1/2" to 7"
- Anodized gold wheels
- One person can move any size scope quickly and easily
- Ideal for the new Meade RCX Series
- Ideal for scopes up to 36"

$265.00
Plus S&H, Approx.
$30 Shipping USA

SCOPEBUGGY
P.O. BOX 834
Elephant Butte, NM 87935

Toll Free
866-312-8449

Patent Pending

Shipping weight 36 lbs.
shipped UPS ground

We Accept :
VISA • MASTERCARD • AMERICAN EXPRESS
PAYPAL • MONEY ORDERS • CASHIERS CHECKS

Please visit us at www.scopebuggy.com

Web Site Directory

Check out these businesses... They're only a click away!

ADVANCED TELESCOPE SYSTEMS
info@advancedtelescope.com
www.advancedtelescope.com
Manufacturing Quality Portable and
Permanent Telescope Piers

ASTROZAP
astrozap@yahoo.com
www.astrozap.com
Your #1 source of dew prevention shields on the planet.
Hundreds in stock! Dew it in style!

BINOCULARS.COM
info@binoculars.com
www.binoculars.com
One of the largest selections of binoculars in the world!
1-800-246-6285

EFSTONSCIENCE
sales@telescopes.ca
www.telescopes.ca
Science & Astronomy SuperStore since 1970.
Canada's best prices selection and staff.

KHAN SCOPE CENTRE
info@khanscope.com
www.khanscope.com
Serving Canada & U.S. for over 19 years
Toll Free: 1-800-580-7160
Telescopes & Accessories at Discount Prices

OWL SERVICES
owl1@owlservices.com
www.owlastronomy.com
Special prices on Knight Owl Eyepieces Telescopes • Binoculars!
FREE # 1-888-OWL-WARE
10-6 EST M-F

TELESCOPES.COM
info@telescopes.com
www.telescopes.com
One of the largest selections of telescopes in the world!
1-800-303-5873

For advertising information call
Ken Kozerski at:
1-888-558-1544
ext. 636

Astronomy

COURTESY D.J. THOLEN

NEXT MONTH

Asteroid's fatal attraction
When Apophis passes 23,000 miles from Earth in 2029, it will be wracked by tides and hurled into a new orbit.

Black-hole kicks
When black holes collide, gravitational waves slingshot them on a frantic deep-space journey.

Searching for signs of life
Astronomers seeking life on other worlds first must understand how Earth would appear from far away.

Titan from the ground up
Saturn's largest moon has methane rivers and possibly volcanoes that spew ammonia-ice lava.

Red Planet rendezvous
Fly over Mars' rugged Valles Marineris and witness mammoth landslides, steep cliffs, and whirling dust devils.

The little comet that might
Uncertainty about how bright Comet 73P/Schwassmann-Wachmann 3 will appear makes it a must-watch object this spring.

Astronomer for a night
Kitt Peak National Observatory's observing programs offer a unique fantasy camp for amateur astronomers.

SUBSCRIBE TODAY!
800.533.6644
ORDER ONLINE AT
Astronomy.com

APRIL 26–30, 2006

The Mid-South Star Gaze draws sky-watchers throughout the southeastern United States to the Rainwater Observatory and Planetarium in French Camp, Mississippi. The star party offers amateur astronomers an opportunity to observe under dark skies, compare instruments, and share tips with fellow astronomy aficionados.

JAMES HILL

THE RAINWATER OBSERVATORY and Planetarium is a large compound created by the French Camp Academy that also features a classroom, amphitheater, and library. It holds 16 telescopes, including a 32-inch Tectron.

While most participants come for observing, some attend for lectures and exhibits. The star party also offers a workshop for teachers.

For more information, call the observatory hot line at 662.547.6377; e-mail, info@rainwaterobservatory.org; web site, www.rainwaterobservatory.org.

MARCH 25

All Arizona Messier Marathon

Farnsworth Ranch, near Arizona City, Arizona. Sponsored by the Saguaro Astronomy Club, this event begins in the early evening and will last through the night. See how many deep-sky gems you can spy before the Sun rises. Those who observe 50 or more Messier objects will receive a certificate acknowledging this accomplishment. For more information, visit www.saguaroastro.org.

MARCH 31–APRIL 2

Tennessee Spring Star Party

Fall Creek Falls State Park, Pikeville, Tennessee. Sponsored by the Cumberland Astronomical Society, this is a beginner-friendly star party, and admission to this public event is free. Surrounded by a large nature preserve, this dark-sky site should provide quality views. For more information, e-mail spsmith@bellsouth.net; web site, cumberlandastronomicalsociety.org.

APRIL 6–9

National Science Teacher Association National Conference

Anaheim, California. This convention showcases the latest in science content, teaching strategies, and research. The conference will feature lectures, field trips, short courses, social events, and a large exhibition of science-education materials. For more information, visit www.nsta.org.

APRIL 20–23
Georgia Sky View
Indian Springs State Park, Jackson, Georgia. This annual event, hosted by the Flint River Astronomy Club, is the premier event for Atlanta-based skywatchers. With attendance limited to 150 people, be sure to register early. No walk-ins will be admitted. For more information, e-mail sdknight@flintriverastronomy.org; web site, www.flintriverastronomy.org.

APRIL 20–23
Southern New Mexico Star Party
City of Rocks State Park, Faywood, New Mexico. Hosted by the National Public Observatory, this biannual event is held at a remote, scenic state park with an elevation of 5,500 feet (1,676 meters), ensuring dark skies. For more information, e-mail jgilkiso@zianet.com; web site, astronomy-national-public-observatory.org.

April 21–23
Girl Scouts Adult Leaders Astronomy Camp
Mt. Lemmon Observatory, Coronado National Forest, Arizona. Part of the University of Arizona's astronomy-camp series, the weekend will be a hands-on experience for Girl Scouts volunteers. Participants will use Mt. Lemmon's two 60-inch telescopes. Daytime activities include solar observing, lectures, hiking, and tours of the facilities, including the university's mirror laboratory. For information on this and other astronomy camps, call Don at 520.621.4079; e-mail, dmccarthy@as.arizona.edu; web site, www.astronomycamp.org.

APRIL 21–22
North Central Region of the Astronomical League Convention
Appleton, Wisconsin. This gathering is the 60th annual convention and 20th anniversary of the host group NEWSTAR. This milestone event will feature an impressive roster of speakers, including Apollo 17 astronaut Harrison Schmitt, Cassini scientist Carolyn Porco, and Vatican astronomer Guy Consolmagno. *Astronomy* Assistant Editor Jeremy McGovern will attend. For more information, visit www.new-star.org.

APRIL 26–30
Desert Sunset Star Party
Caballo Loco Ranch RV Park, near Tucson, Arizona. The Whipple Observatory will offer a daylong tour on the Friday during the star party. Visits to Pima Air and Space Museum, Kitt Peak National Observatory, and other nearby astronomical sites provide alternatives to observing. For more information, visit chartmarker.tripod.com/sunset.htm.

MAY 5–6
Northeast Astronomy Forum and Telescope Show
Rockland Community College, Suffern, New York. This annual gathering features lectures by prominent astronomers. *Astronomy* Editor David J. Eicher will attend. For more information, visit www.rocklandastronomy.com.

MAY 26–28
Riverside Telescope Makers Conference (RTMC)
YMCA Camp Oakes, near Big Bear City, California. The RTMC is usually the most popular astronomy gathering in the Golden State. This year's theme is "Preserving and Enjoying the Night Sky." Featuring clear, high-altitude observing, workshops, and lectures, this event draws stargazers from around the world. *Astronomy* Associate Editor Laura Layton will attend. For more information, visit www.rtmcastronomyexpo.org.

CONTACT INFORMATION

Please submit club announcements 4 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our online calendar.

INDEX *of* ADVERTISERS

Adorama, 74, 75
Ash Manufacturing, 98
Astro Haven, 99
Astro-Physics, 100
Astronomics, 12- 13, 98
Astronomy Delight, 99
Astronomy magazine, 96
Astronomy magazine Tour, 88
Astronomy Special Issue, 89
Astronomy.com, 22
Atomic Time, 88
Beam of Light Technologies, 100
Beta Electronics, 99
Bethany Sciences, 100
Binoculars.com, 99
Birder's World magazine, 81
Celestron, 105
Coronado Technology Group, 9
Denkmeier Optical, 100
Equatorial Platforms, 100
Flagstaff Convention & Visitors Bureau, 21
Glatter, Howard, 99
Hands on Optics, 74
Into the Wind/The Kite Source, 99
Jim's Mobile Inc, 74
Kitt Peak National Observatory, 88
LuckyDuck.com, 95
Lumicon, 17
Marketplace Pages, 98-100
Meade Instruments Corp, 2, 3, 7, 8,106
Oceanside Photo & Telescope, 21, 74
Orion Telescopes & Binoculars, 19, 23
Pegasus Optics, 98
Rainbow Symphony, 100
Relief Globe Company, 99
Ritz Camera Superstores, 100
Rivers Camera Shop, 33
Round Table Equatorial Platforms, 98
SAC Imaging Systems, 100
Satwhere.com, 99
Scope Buggy, 95
Scope City, 33
Scope Stuff, 98
ScopeTronix, 27
SCS Astro, 99
Shutan Camera & Video, 88
Smartastronomy.com, 98
Software Bisque Inc., 30, 31
Solarscope, 98
Stargazers Inn, 98
Starstone Software Systems, 99
Stellarvue, 98
Technical Innovations, 95
The Teaching Company, 29
Tele Vue Optics, Inc, 15
Van Slyke Engineering, 98
Vixen, 25
Website Directory, 95
William Optics Co., 22
Wireless Focuser, 98
Woodland Hills Photo Images, 22
www.bigbinoculars.com, 99

SmartAstronomy
Authorized
Meade Dealer

Visit our Web Store & see MORE !

SmartAstronomoy.com
888.291.6577

DISCOVER
THE SUN...
847-579-0025
www.solarscope.com

ScopeStuff
Telescope Accessories & Hardware
www.scopestuff.com
512-259-9778

StarGazers
Inn & Observatory
Nightly StarGazing in Private Observatory
Luxury B&B in Big Bear Lake, CA Offers Romance Under the Stars! Queen Featherbeds, Fireplaces, Candlelit Spa Tubs, Indoor Heated Pool, Sauna, Game Room, & More!
866-482-STAR (7827) www.stargazersinn.com
- Mention this ad for discount -

ROUND TABLE PLATFORMS

DOBSONIAN TRACKING PLATFORMS
QUALITY MADE - AFFORDABLE PRICES
847-202-1986
www.roundtableplatforms.com

ONE MILLION
LIGHT YEARS

IN LESS THAN
ONE MINUTE

The Stellarvue Nighthawk 2 on our new smooth and stable M1 mount and grab and go tripod. The Nighthawk 2 uses our own highly rated, hand-figured, Nighthawk Classic airspaced lens in an adjustable cell. Prices start at only $399 for the ota and case.

STELLARVUE®
SEEING IS BELIEVING
WWW.STELLARVUE.COM
(530) 823-7796

WirelessFocuser.com™
Patent Pending
For Rack
and Pinion Focusers

PEGASUS OPTICS - Mirrors
★ Wavefront P-V <1/8 wave ★ 1.6 -2" thick ★IAD Coating

Dia.	FL	Price	Dia.	FL	Price
18"	80"	$2500	22"	100"	$4000
20"	100"	$3200	24"	110"	$5100

"You'll see the difference"
Web Site: PegasusOptics.Com E-mail: hallj@direcway.com
TEL: (830) 538-9499

FOCUS ON
NORTHERN OKLAHOMA COLLEGE OBSERVATORY
Enid, Oklahoma

The Ash-Dome pictured is our 16'6" diameter unit. Housed is a 14-inch Schmidt-Cassegrain telescope equipped with a CCD camera and spectrograph. Students enrolled in astronomy are able to conduct research. The Astronomy Department encourages local students of all ages and astronomers in the community to collaborate with undergraduate students. The NOC Observatory has hosted over 800 visitors over this past academic year.

ASH MANUFACTURING COMPANY
P.O. Box 312
Plainfield, IL USA 60544
815.436.9403 • FAX 815.436.1032
web site: www.ashdome.com
email: ashdome@ameritech.net

ASH-DOME is recognized internationally by major astronomical groups, amateurs, universities, colleges secondary & primary schools for their performance durability and dependability. Manual or electrically operated units in sizes from 8 to 30 feet in diameter; sensibly priced. Brochures and specifications available.

Dielectric diagonals starting at $69.95!

These high quality **Astronomy Technologies** star diagonals increase light transmission *and* improve planetary contrast and detail when compared with the so-so prism diagonal usually supplied with new telescopes.

The quality construction **Astro-Tech** star diagonals have durable 99% reflectivity *46-layer dielectric* first surface mirror coatings and a non-marring compression ring eyepiece holder. The 2" diagonals also have a 1.25" compression ring eyepiece adapter and your choice of either a standard 2" nose piece to use with a refractor or with a threaded ring to connect to a Schmidt-Cassegrain rear cell.

Here are the **Astro-Tech** dielectric prices:

1.25" dielectric star diagonal	**$69.95**
2" dielectric w/1.25" adapter	**139.95**
2" SCT dielectric w/1.25" adapter	**149.95**

ASTRO-TECH
from Astronomy Technologies
Astro-Tech products are available at these dealers:
www.astronomics.com
www.highpointscientific.com

VSE LIGHT-YEARS BEYOND!
COPIED BY MANY, BUT NEVER DUPLICATED!
Your SCOPE & CAMERA isn't Enough!
To do Great Astroimaging, you Need VSE

Visa/MC
RIVALED BY NONE, ENVIED BY ALL!
VAN SLYKE ENGINEERING
12815 Porcupine Lane, Colorado Springs, CO 80908
Voice: 719.495.3828 FAX: 719.495.6465
WWW.OBSERVATORY.ORG

bigbinoculars.com
Astronomical binoculars (50-150mm)
and accessories at down-to-earth prices.
Toll free- 866-244-2460 (BIG-BINO)
www.bigbinoculars.com
OBERWERK FUJINON

SW SATWHERE
THE ULTIMATE SATELLITE
TRACKING AND
EARTH VIEWER SOLUTION!
www.SATWHERE.com

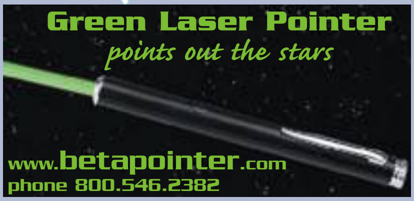
Mars Globe 20x for $599
reliefglobe.com
1-831-338-1726

Sometimes, one plus one is equal
to much more than two . .
This is one of
those times
Introducing . .
Patent
Pending
Howie Glatter's Binocular Platform
for the Coronado© PST - $385
Interpupillary distance adjustable from 60mm
Weatherproof Aluminum Superalloy and
Stainless Steel construction
Optional Universal Astronomics alt-az Microstar
mount (pictured with handle) - $187
Howie Glatter's Full Line Astronomical
Collimators, SkyPointers and Brackets on the Web
Howie Glatter 3850 Sedgwick Ave #14F
Bronx, NY 10463 Tel/Fax (718) 796-3203
www.skypointer.net www.collimator.com
e-mail: howieglatter@mindspring.com
CORONADO
PST

KITES!
Since 1980, we've made it our mission
to fly and sell the best kites in the world.
FREE color catalog with hundreds of kites,
flags, windsocks and spinners, or shop online at:
www.IntoTheWind.com
1408-A Pearl St., Boulder, CO 80302 • (800) 541-0314

EUROPE'S PREMIER WEBSITE
http://www.scsastro.co.uk
SCS ASTRO

The Fourth Day™
3D Astronomical Clock and Almanac
Download & Try Free
starstonesoftware.com


Green Laser Pointer
points out the stars
www.betapointer.com
phone 800.546.2382

Can you imagine...
Owning your own fun
Astronomy Delight! franchise
with unlimited profit potential?
Enormous untapped markets
Virtually no overhead - Co-op advertising
No royalties - Full equipment setup
Personal training - Work your own schedule
Income range well over $100 - $500 per hour!
Even the ability to sell quality telescopes from
premiere manufacturers! All for only
$9,500.00!
Join our growing nationwide team!
Astronomy Delight!
www.astronomydelight.com 845-229-4434
MI - CA - Tri-State NY - GA - MO

ASTRO HAVEN
Non-Rotating Clamshell Domes
- 7' or 12' Diameter
- Low Maintenance
- Fast Erection
- Low Cost
Full 180° Viewing Radius
5650 Production Way, Langley,
British Columbia, Canada V3A 4N4
Phone
(604) 539-2208
Fax
(604) 539-2209
www.astrohaven.com e-mail: domesales@astrohaven.com
12 ft
7 ft
ASTRO HAVEN

TeleVue
Visionary
@
Telescopes.com
Why settle for
anything less!
All TeleVue products
are In Stock.
Telescopes.com
Binoculars.com
Spottingscopes.com
1.800.303.5873

DENKMEIER

Visit the Denkmeier Optical Online Store!

NEW!
The Big Easy
$399+s&h

26mm Prisms!

*A donation of $10 will be made to the Red Cross for the Hurricane Katrina Relief Effort for each **Big Easy Package** sold for a period of one year.*

The Big Easy binoviewer package features our famous 26mm clear aperture binoviewer and *includes* our patent pending modular Optical Corrector System or "OCS" (USPTO #20040150882) allowing focus at multiple magnifications in Refractors, Newtonians & SCTs. Large prisms fully illuminate typical long focal length eyepieces even in focal reduction mode in SCTs! You only need one pair of eyepieces because SCTs operate at reduction, normal and 2X powers! Refractors & Newtonians operate at both low & high Powers. Visit The Denkmeier Online Store today!

Power X Switch™ Star Diagonals!

We offer 4 versions of our patent pending Power X Switch Star Diagonals. For SCTs and single eyepieces, you will never have to use a Barlow or focal reducer again! Why? Because our Power X Switch Diagonal #S1 already has a built-in focal reducer and 2X Barlow, available on demand and instantly. Normal power is instant as well. This is why #S1 was named as Hot Product of 2005 in S&T. View *every* object at 3 magnifications in seconds! The other versions have been designed to allow binoviewers to reach focus at multiple magnifications. Visit our new Online Store for all of the details & to place an order. 30 day refund guarantee on any product!

http://denkmeier.com
** Featuring our secure shopping cart. **
Order Toll-Free:
(866) 340-4578
We accept all major credit cards.

TRACKING for DOBS
* High power observing and group viewing
*Astro-imaging with NO field rotation
call write or e-mail for free brochure
EQUATORIAL PLATFORMS 530-274-9113
15736 McQuiston Lane Grass Valley CA 95945
tomosy@nccn.net www.equatorialplatforms.com

METEORITES

Museum-Quality collectors' specimens. Meteorite jewelry, books, unique gift items. Authenticity guaranteed.

Color Catalog
$3 USA, Canada and Mexico
$6 Foreign
Refundable with order.

The Universe Collection
P.O. Box 3726-A, New Haven, CT 06525-0726
203 393-3395 *fax* 203 393-2457

www.universecollection.com
VISA • MC • AMEX

SAC IMAGING
Entry level imaging
www.sac-imaging.com
321-259-6498

SAC4 1.2 mega pixel $229
SAC8.5 still one of the most sensitive cameras on the planet. $549
SAC10, 3.3 mega pixel 48 bit color $900

ASTRO-PHYSICS
Experience the ultimate in quality instruments for discriminating observers and astrophotographers.
Telescopes, Go-To German Equatorials, Visual and Photographic Accessories
Unparalleled Service and Support

Experience the legend that is
ASTRO-PHYSICS!

160mm f7.5
StarFire EDF
900GTO

11250 Forest Hills Road
Machesney Park, IL 61115, USA
Ph: 815-282-1513, Fax: 815-282-9847
www.astro-physics.com

ECLIPSE SHADES™
Safe Solar Viewers
Custom Imprinting Available

SAFE FOR DIRECT SOLAR VIEWING
CE Certified

The ultimate in protection from harmful solar radiation. Lenses are made of our exclusive scratch resistant optical density 5, "Black Polymer" material. Eclipse Shades filter out 100% of harmful ultra-violet, 100% of harmful infrared, and 99.999% of intense visible light. These premium filters create a sharper ORANGE colored image of the sun.

Rainbow Symphony, Inc.
6860 Canby Ave. #120, Reseda, CA 91335
(818) 708-8400 • Fax (818) 708-8470
eclipse@rainbowsymphony.com
www.rainbowsymphony.com/soleclipse.html

WOLFCAMERA
OUR EXPERTISE IS FREE!

EXPERTISE: Chuck Pisa, our staff astronomer, has 20 years experience recommending optical instruments to amateurs and professionals at our Sarasota location. You can e-mail questions to Chuck at cpisa@mindspring.com

SELECTION: We have a HUGE selection of products from telescopes, binoculars and CCD cameras to filters and eyepieces. If it's astronomy-related, we have it! We carry Meade, Celestron, TeleVue, and Apogee as well as a selection of used telescopes.

SARASOTA, FL
2069 Siesta Drive
(941) 955-3537 • (941) 366-8640 fax

www.z-bolt.com

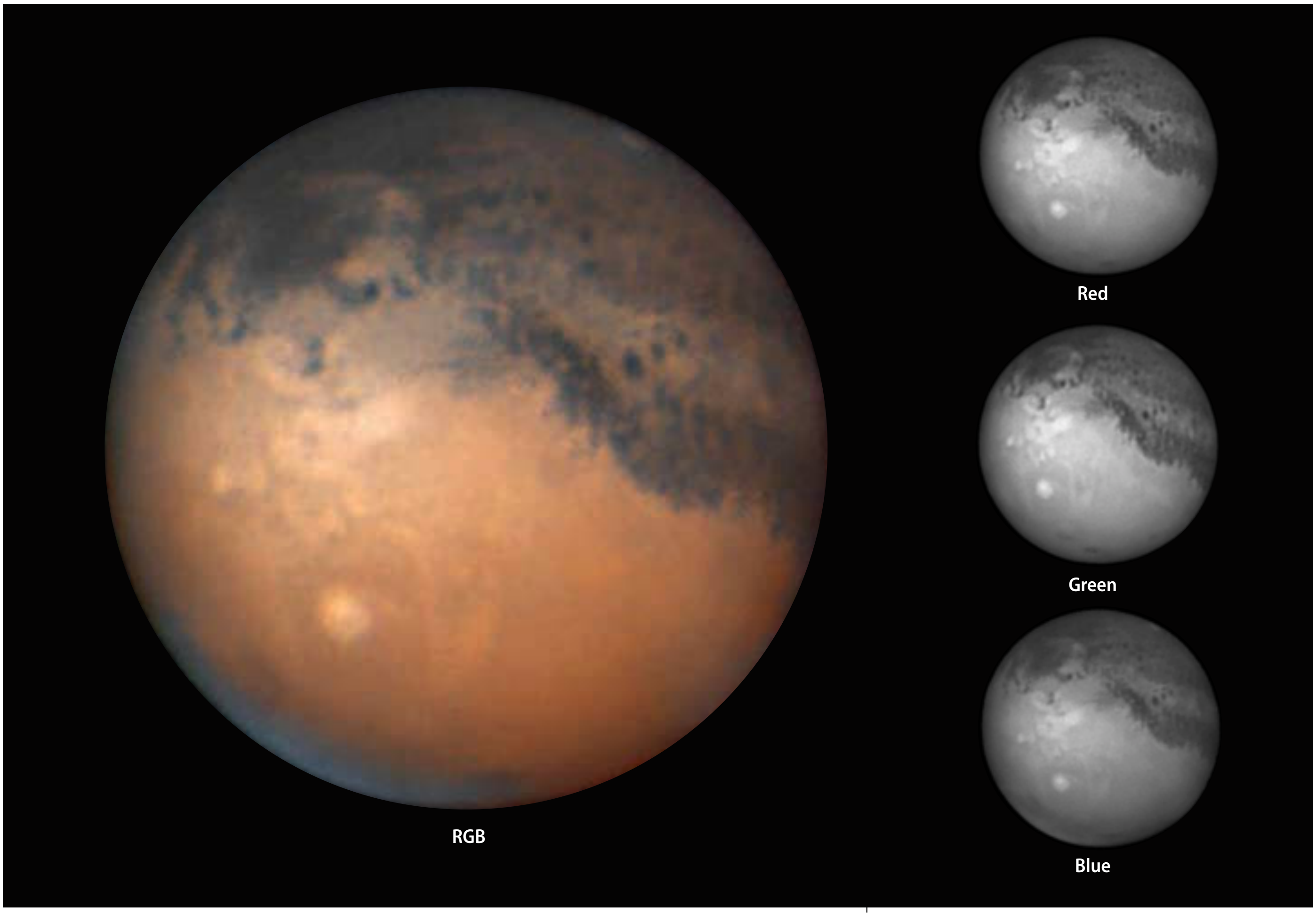
Green Lasers for
Star Pointing
Star Finders
Scope Mounting

Constant On Green Lasers - $ 55.00
Custom Engraved Green Lasers - $ 69.00
Lithium Powered Green Lasers - $ 79.00
True 5mW Factory Tuned Greens - $ 89.00

Enter *Astronomy Magazine* Code 532 at our Online Store. Receive 10% off ALL *Astronomy* Category Models!! Faxed PO's accepted for universities, corporations, government agencies, and the U.S. Armed Forces.

Beam of Light Technologies, Inc.
Toll Free: 877-801-9299
Fax: 603-309-6020

Reader gallery

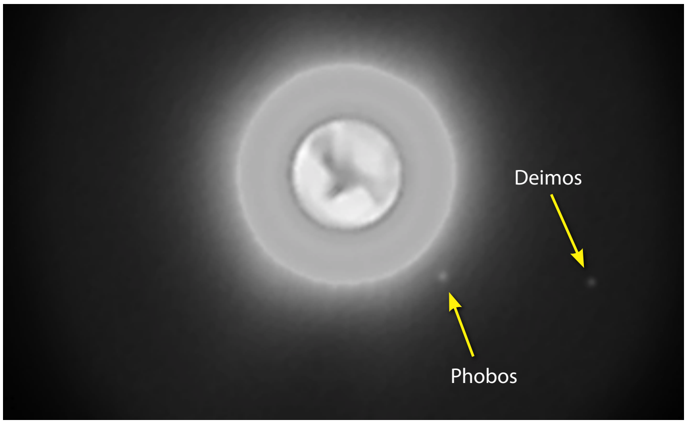


MARS (14-inch Celestron Schmidt-Cassegrain telescope at f/40, Lumenera Lu075M CCD camera, RGB image taken November 6, 2005, between 22h59m UT and 23h30m UT)
/// DAMIAN PEACH, LOUDWATER, ENGLAND

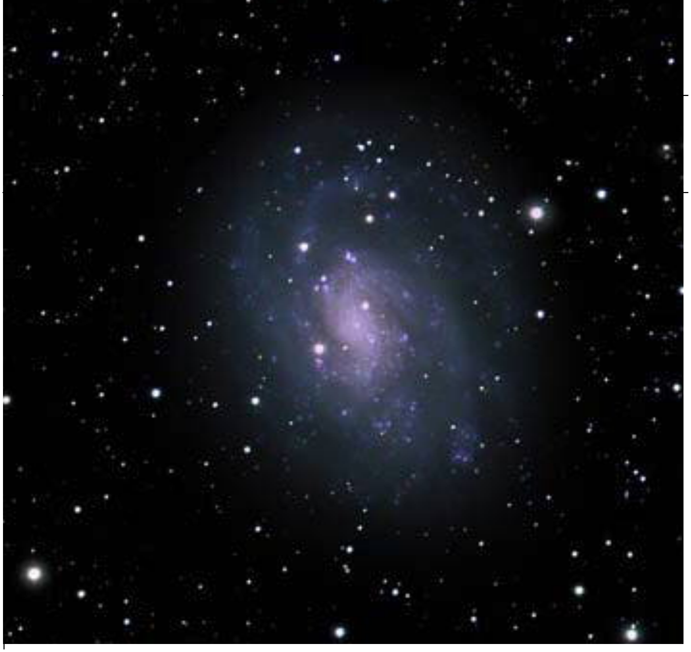
RED PLANET SPECTACULAR

The best Mars yet

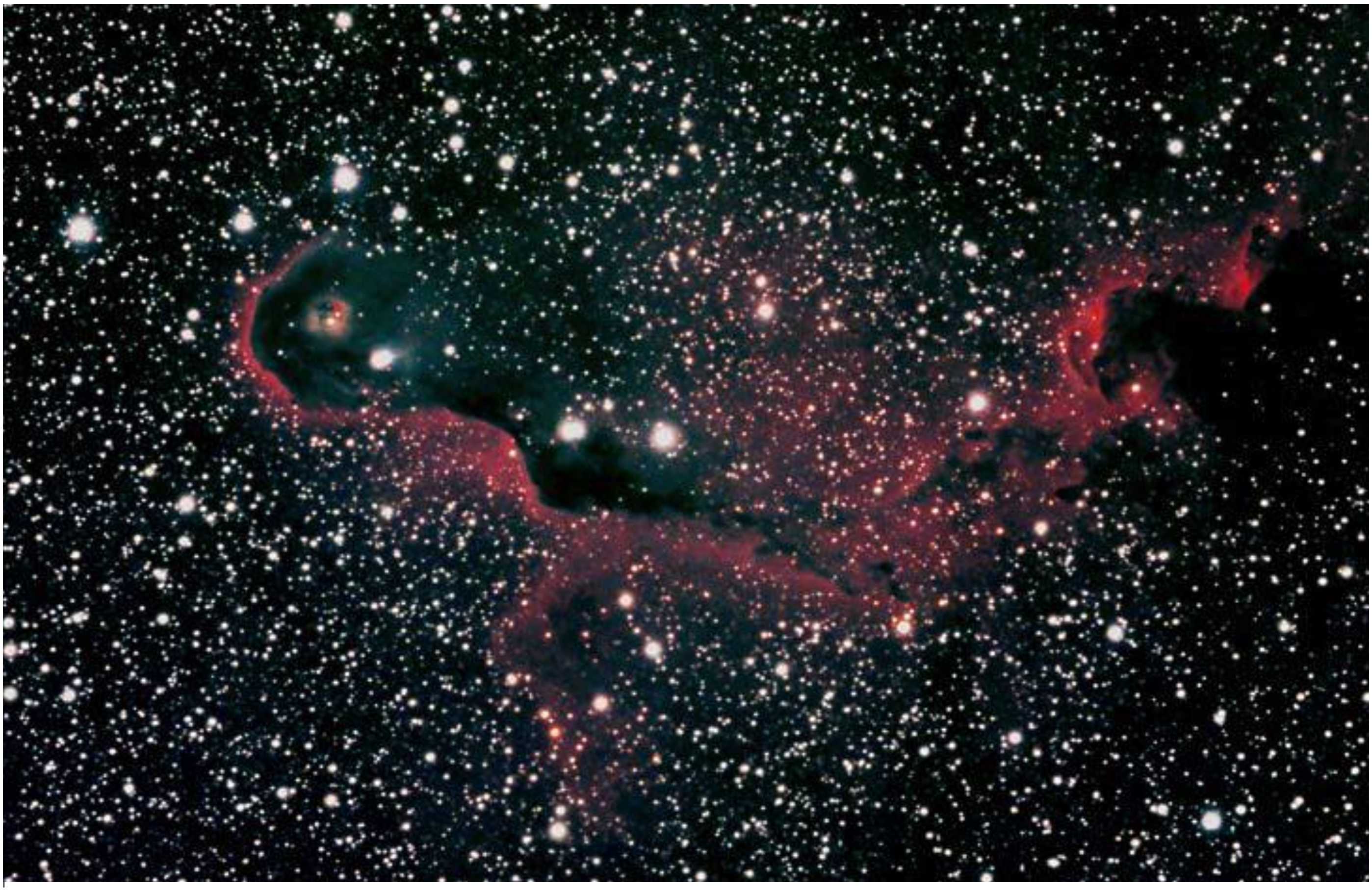
On October 30, 2005, Mars approached within 43,153,000 miles (69,449,000 kilometers) of Earth. The Red Planet looked as big and bright as it would be until 2018. Although Mars was closer and more luminous during its 2003 close approach, the planet climbed more than 30° higher in the sky for Northern Hemisphere observers. Because imagers shot through less of Earth's distorting atmosphere, their images surpassed those from previous close approaches. The image above, taken through a camera having only 640x480 pixel-resolution, marks one such example.



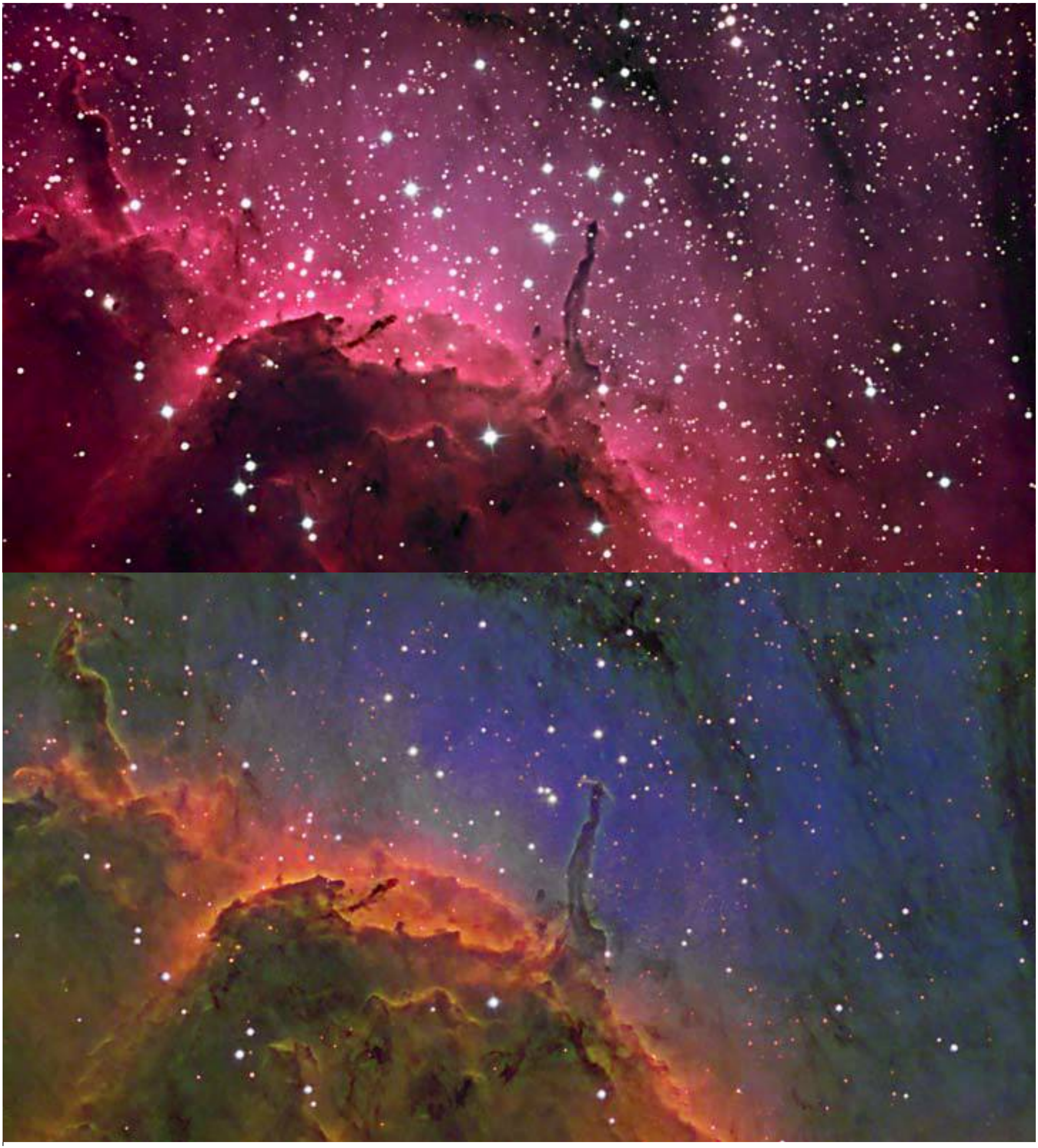
PHOBOS AND DEIMOS glow faintly next to brilliant Mars. (9.25-inch Celestron Schmidt-Cassegrain telescope at f/10, Philips ToUcam Pro webcam, Mars image compiled from 754 1⁄50-second frames, Phobos and Deimos images compiled from 901 1⁄25-second frames, taken November 3, 2005, at 2:05 A.M. EST) /// CHRIS COOK, EAST DENNIS, MASSACHUSETTS



SPIRAL GALAXY NGC 300 lies 6.1 million light-years away in Sculptor. Astronomers classify NGC 300 as type Sc, which means it has spiral structure with loosely wound arms. (3.2-inch Orion ED80 apochromatic refractor at f/7.5, Starlight Xpress HX916 CCD camera, LRGB image with exposures of 80, 32, 32, and 32 minutes, respectively) /// RICH BOWDEN, STREAKY BAY, AUSTRALIA

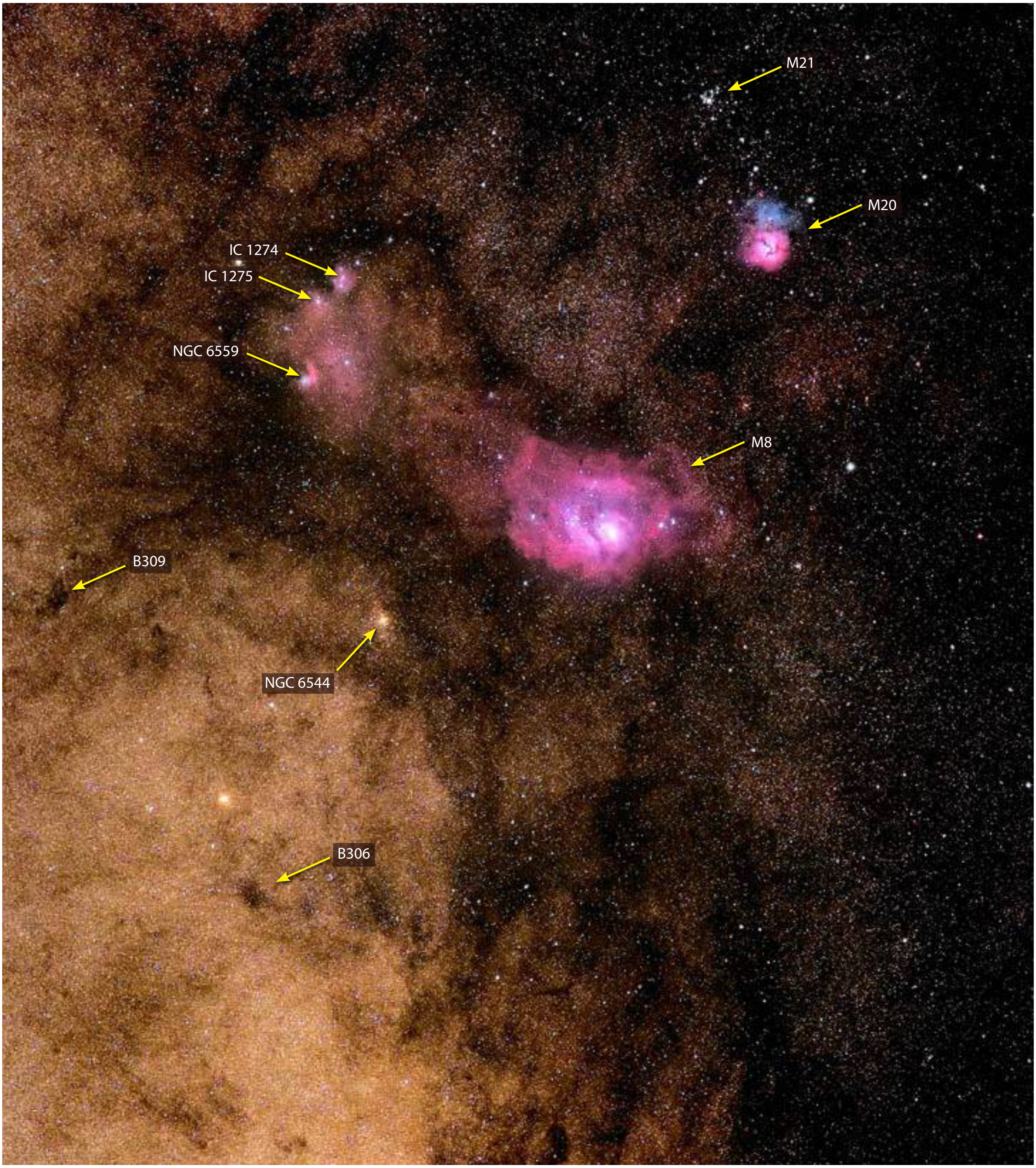


THE ELEPHANT TRUNK NEBULA (Van den Bergh 142) in the northern constellation Cepheus belongs to the much larger IC 1396 nebula complex. Astronomers refer to VdB 142 as a cometary globule, but only because it roughly resembles a comet. During millions of years of slow collapse, such areas form stars. (8-inch TMB 203 apochromatic refractor at f/9, SBIG STL-6303E CCD camera, LRGB image with exposures of 90, 30, 30, and 30 minutes, respectively) /// PAOLO CANDY, SORIANO NEL CIMINO, ITALY



IC 5067 forms a small part of the "neck" of the Pelican Nebula in Cygnus the Swan. The top image was taken primarily through red, green, and blue filters plus exposures for luminance; the bottom image was taken through Silicon II, Hydrogen-alpha, and Oxygen III filters. (20-inch RC Optical Systems Ritchey-Chrétien telescope at f/8.3, Yankee Robotics Trifid II 6303 CCD camera, Astrodon filters. Top: Hα/unfiltered/RGB image with exposures of 210, 120, 56, 56, and 56 minutes, respectively. Bottom: SiII/Hα/OIII image with exposures of 210, 130, and 110 minutes, respectively)
/// KEN CRAWFORD, RANCHO DEL SOL CAMINO, CALIFORNIA

THE MILKY WAY in Sagittarius contains more than stars. Nebulae, such as the Lagoon Nebula (M8) and the Trifid Nebula (M20), abound, as do star clusters like M21 and dark nebulae, such as B306 and B309. (Canon 20Da digital SLR, Skywatcher EQ6 equatorial mount, Canon 200mm f/1.8 lens, 2-minute guided exposure at f/2.2, ISO 800)
/// JAY OUELLET AND BRADY JOHNSON, QUÉBEC CITY



Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement # 40010760.

A modern day classic.

Easy as 1-2-3!

SkyAlign™

Revolutionary New Alignment Technology

NexStar 8i Special Edition: classic look, cutting edge features. Now with SkyAlign technology!

The orange tube C8 is the most recognizable symbol of Celestron and its place in telescope history. The heritage of our classic orange tube telescopes has carried through to our newest generation of products that include this 8i Special Edition – high quality optics and revolutionary portable designs remain the foundation for the products we engineer today.

NEW FEATURES!

- SkyAlign Technology: the fastest and easiest alignment in the universe. Point the 8i SE at three bright objects in the sky (no need to know the names of the objects) and the telescope figures out the rest. **Celestron's SkyAlign technology has been selected as one of the hot new products for 2006 by Sky and Telescope magazine.**
- Flash Upgradeable: conveniently upgrade your 8i SE operating software via the Internet.

8i special edition

[1] Celestron's renowned Schmidt-Cassegrain optical system with metallic orange tube color, signature special edition logo and STARBRIGHT® XLT Coatings.

[2] Designed For Portability: At only 24 lbs. this is the most portable 8" telescope available. Spend more time observing with this lightweight and easy to set-up telescope.

[3] Single Fork Arm Design: patented design with integrated hand control provides a rigid and smooth operating platform for the 8i's optical tube.

[4] Heavy-duty tripod with metal accessory tray.

[1]

[2]

[3]

[4]

Brains and beauty packed in one of the lowest priced 8" Schmidt-Cassegrain computerized telescopes on the market.

NexStar 8i Special Edition (8")	$1399.00

shipping and handling $60.00

Suggested retail in U.S. Dollars. Pricing and shipping charges are suggested for products ordered and shipped in the U.S.A. only.

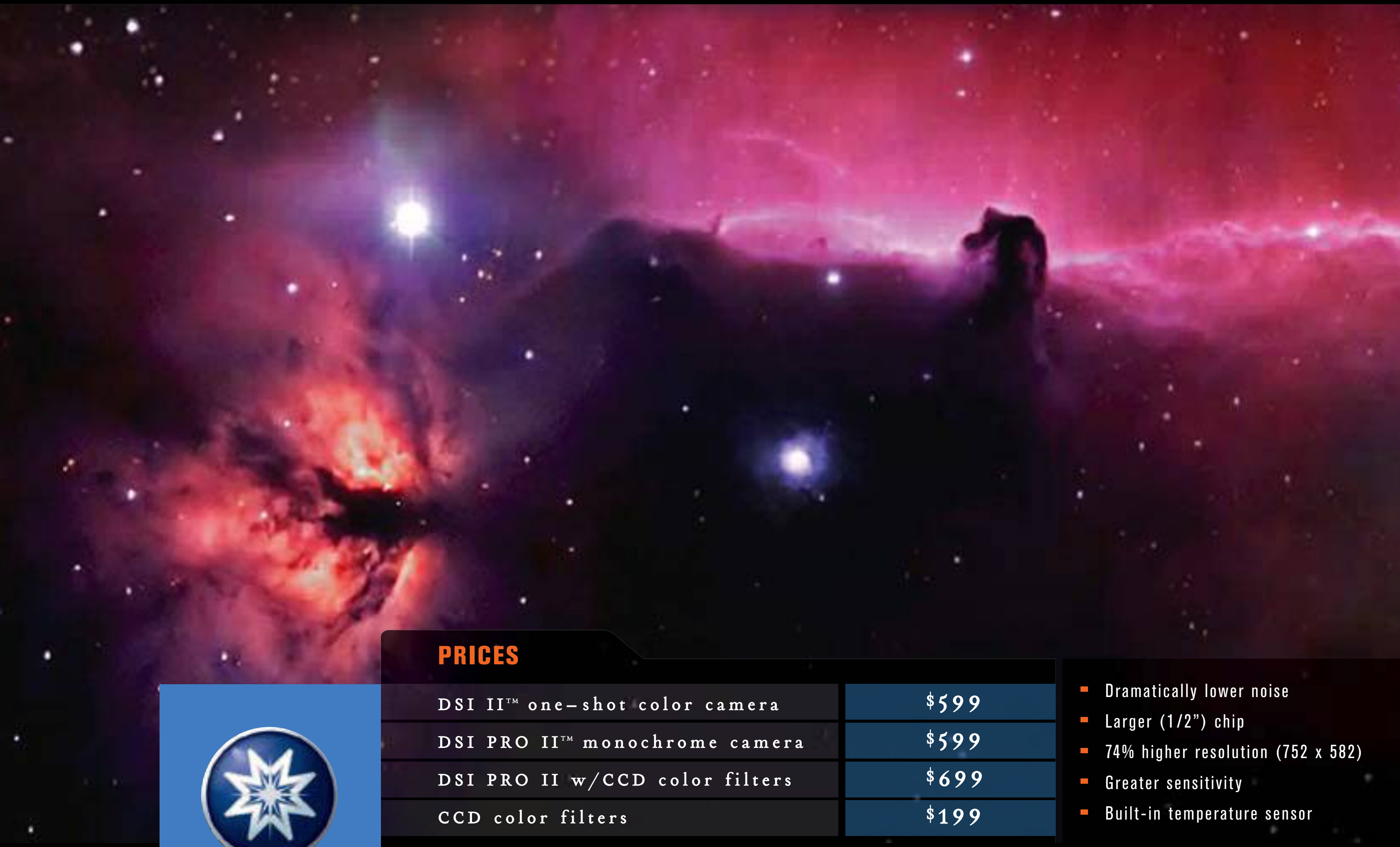
CELESTRON®

www.celestron.com/8ise

AUTHORIZED CELESTRON DEALER

ADORAMA	800.223.2500	www.adorama.com
OCEANSIDE PHOTO AND TELESCOPE (OPT)	800.483.6287	www.optcorp.com
ASTRONOMICS	800.422.7876	www.astronomics.com
B&H PHOTO	800.947.9970	www.bhphotovideo.com
TELESCOPES.COM	800.303.5873	www.telescopes.com
SCOPE CITY	800.235.3344	www.scopecity.com

I have yet to take a bad image with my DSI Pro II. – Mark Sibole



PRICES

DSI II™ one-shot color camera	$599
DSI PRO II™ monochrome camera	$599
DSI PRO II w/CCD color filters	$699
CCD color filters	$199

- Dramatically lower noise
- Larger (1/2") chip
- 74% higher resolution (752 x 582)
- Greater sensitivity
- Built-in temperature sensor

MEADE®

Autostar Suite
MEADE

* DSI Pro II shown above

The user-friendly astrophotography revolution continues. Introducing the new DSI II. It combines ease-of-use with a larger chip, greater sensitivity, higher resolution, and dramatically lower thermal noise. Meade engineers have invented a remarkable new way to reduce noise without a cooler. This means you can take exposures for hours at a time. And the new thermal monitoring sensors automatically match your dark frames to ambient temperature so it's nearly impossible to take an uncalibrated picture. The software includes a new zoom feature for easier focusing and the squared pixels of the new larger chip make processing simpler and images more beautiful than ever. The DSI II is the world's first un-cooled camera with low thermal noise. And that's as cool as it gets.

MEADE.COM | 800.919.4053

THE HORSEHEAD AND FLAME NEBULA BY MARK SIBOLE. 4 PANEL MOSAIC; THE FLAME NEBULA – HA = 60MIN., RGB = 12 MIN. PER CHANNEL. THE HORSEHEAD NEBULA – HA = 60MIN., RGB = 20 MIN. PER CHANNEL. 80MM REFRACTOR PIGGYBACK ON 12" LX200 WITH MEADE DEEP SKY IMAGER PRO II. AUTOGUIDED WITH THE DSI PRO.

TELESCOPES.COM (800.958.6040) • ASTRONOMICS (800.356.6603) • OPTICS PLANET (888.263.0356) • OPT CORP. (800.338.9638)
SCOPE CITY (800.235.3344) • ADORAMA (800.223.2500) • B&H PHOTO (800.329.0315) • CANADA – EFSTON SCIENCE (888.396.3233)

30-06007

SPECIAL STARS ISSUE

Making sense of stars

Two early-20th-century astronomers first saw patterns in the rich diversity of stars. /// BY RICHARD TALCOTT; ILLUSTRATION BY LYNETTE COOK

Scan the night sky, and you'll see stars of every hue. The dazzling blue of Rigel contrasts with the ruddy glow of Betelgeuse, and neither would be confused with the pure white of Sirius or the yellow gleam of Capella. Even faint stars, when magnified by a telescope, show a range of colors. What does it all mean?

The answer came through the efforts of Danish astronomer Ejnar Hertzsprung (1873–1967) and American astronomer Henry Norris Russell (1877–1957). In the early 20th century, they independently plotted the intrinsic brightness of stars against temperature (which determines color). Today, astronomers understand stellar diversity with the Hertzsprung–Russell (H–R) diagram, named in the scientists' honor. A modern version appears at right.

The H–R diagram's vertical axis plots a star's brightness, measured in luminosity, or absolute magnitude (the star's apparent magnitude if it were 32.6 light-years away). Bright stars lie near the top; faint stars near the bottom. The horizontal axis plots a star's temperature, or spectral type. Hot, blue stars lie to the left; cool, red stars to the right.

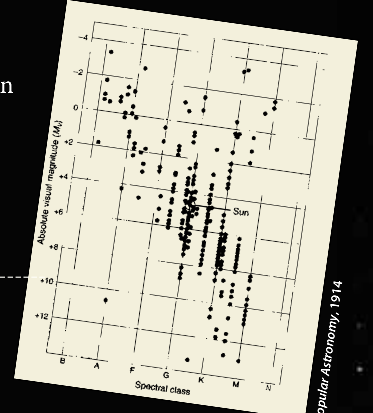
The diagram shows that about 95 percent of stars lie along a narrow strip that runs from upper left to lower right. This so-called main sequence represents stars burning hydrogen into helium. Fewer than 1 percent of stars belong to the giant and supergiant classes at top, even though many of these rank among the sky's brightest. At bottom, the dying cinders known as white dwarfs make up about 5 percent of stars. ▣

AIP Niels Bohr Library

"IT SEEMS CLEAR THAT . . . there is a real lack of red stars comparable in brightness to the Sun."
— *Henry Norris Russell*

AIP Niels Bohr Library

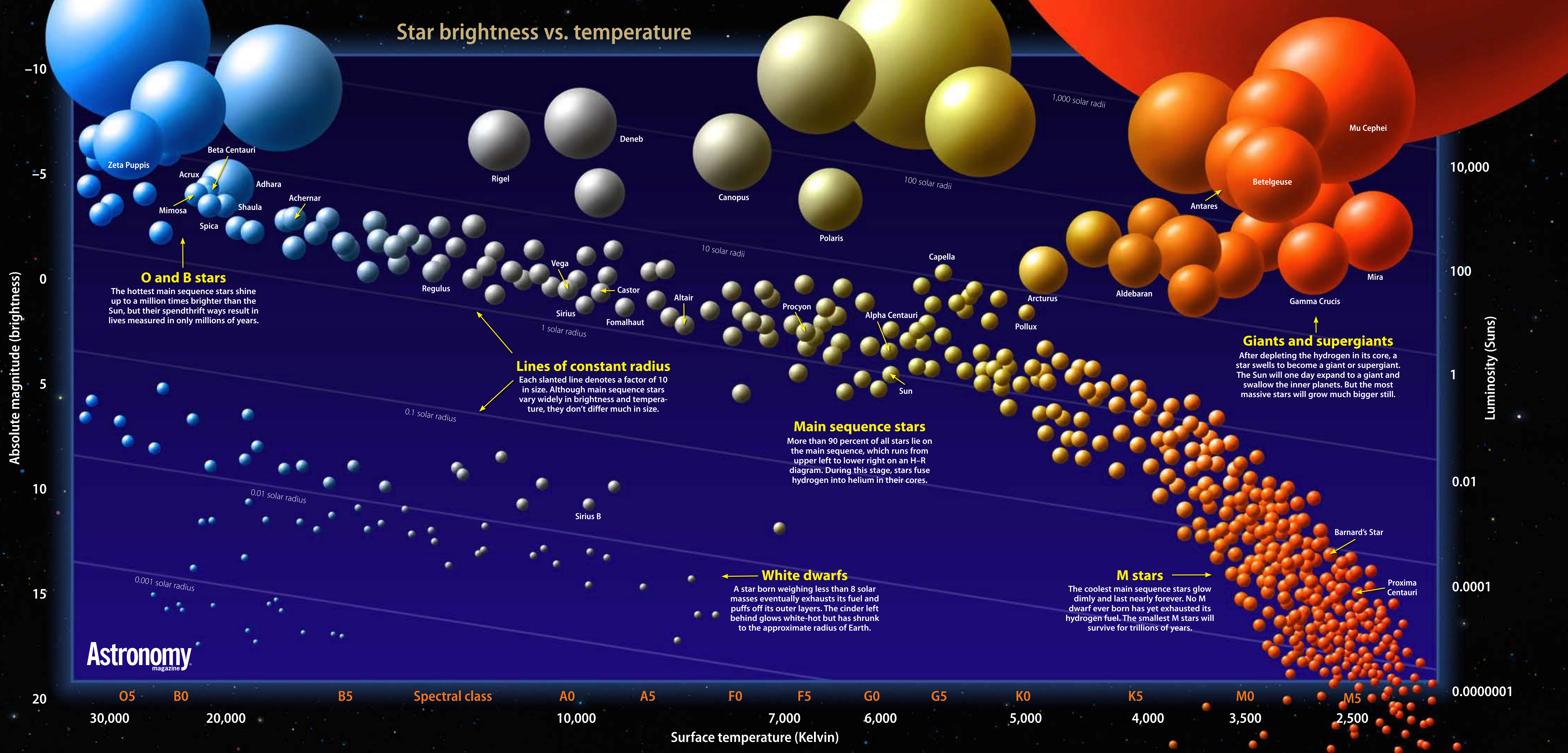
"WHY NOT CALL IT the color-magnitude diagram? Then we know what it is all about."
— *Ejnar Hertzsprung*



Popular Astronomy, 1914

RUSSELL'S ORIGINAL DIAGRAM clearly shows most stars lie on a strip running from upper left to lower right.

Richard Talcott *is the senior editor of* Astronomy. **Lynette Cook** *is an illustrator living in Daly City, California.*



Star brightness vs. temperature

O and B stars
The hottest main sequence stars shine up to a million times brighter than the Sun, but their spendthrift ways result in lives measured in only millions of years.

Lines of constant radius
Each slanted line denotes a factor of 10 in size. Although main sequence stars vary widely in brightness and temperature, they don't differ much in size.

Giants and supergiants
After depleting the hydrogen in its core, a star swells to become a giant or supergiant. The Sun will one day expand to a giant and swallow the inner planets. But the most massive stars will grow much bigger still.

Main sequence stars
More than 90 percent of all stars lie on the main sequence, which runs from upper left to lower right on an H–R diagram. During this stage, stars fuse hydrogen into helium in their cores.

← **White dwarfs**
A star born weighing less than 8 solar masses eventually exhausts its fuel and puffs off its outer layers. The cinder left behind glows white-hot but has shrunk to the approximate radius of Earth.

M stars →
The coolest main sequence stars glow dimly and last nearly forever. No M dwarf ever born has yet exhausted its hydrogen fuel. The smallest M stars will survive for trillions of years.

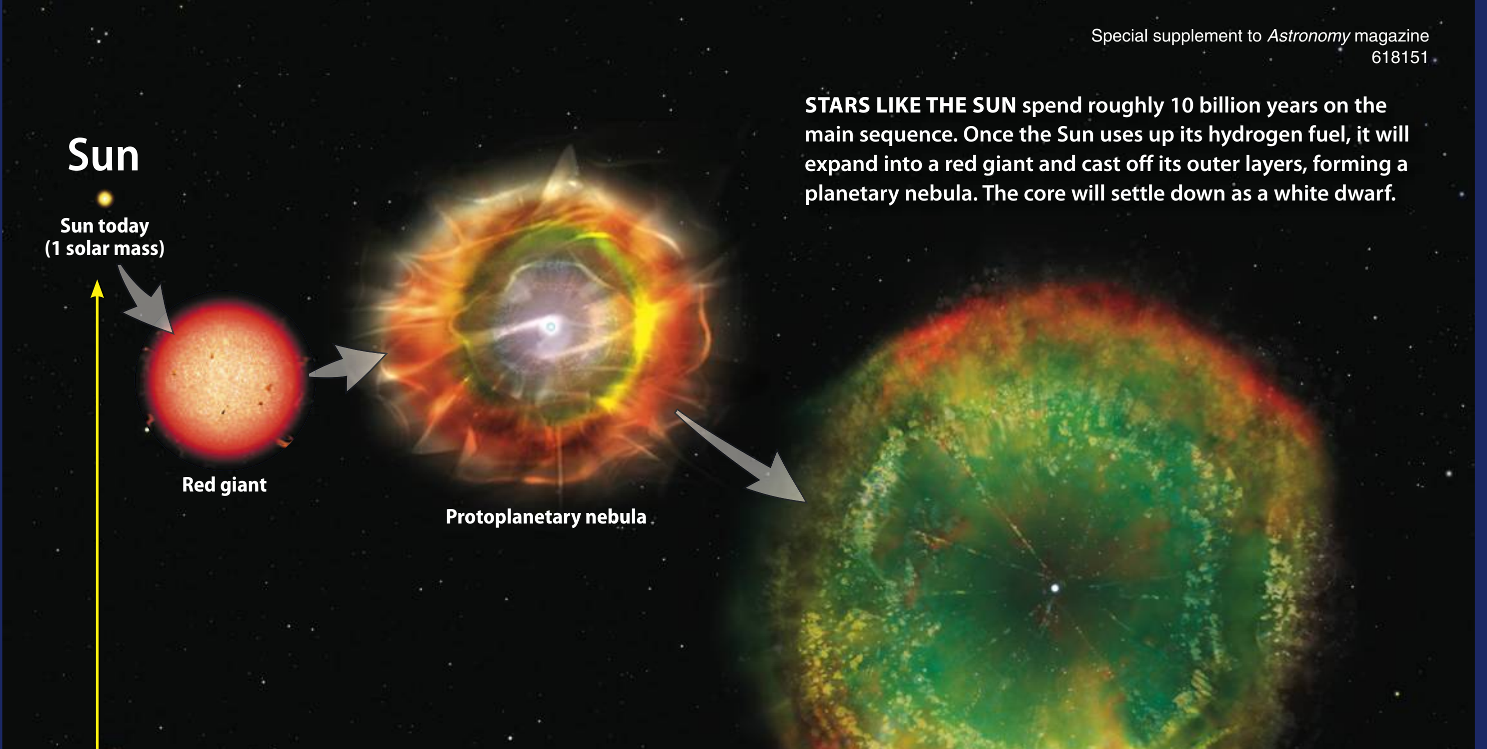
Special supplement to *Astronomy* magazine
618151

NASA/JPL-CALTECH/L. ALLEN (HARVARD-SMITHSONIAN CfA)

STARS FORM INSIDE INTERSTELLAR CLOUDS of gas and dust when an outside force triggers the cloud to gravitationally contract. This natal cocoon, which goes by the prosaic designation W5, lies 7,000 light-years from Earth in Cassiopeia. The infrared radiation captured in this image penetrates the cloud's dust, revealing newborn stars with masses similar to the Sun.

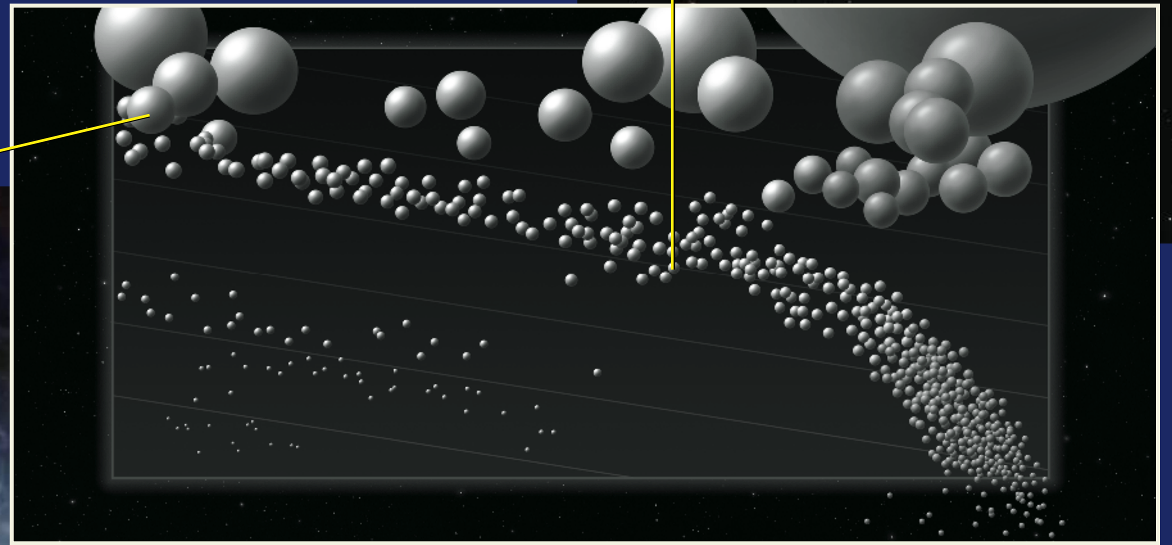
NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

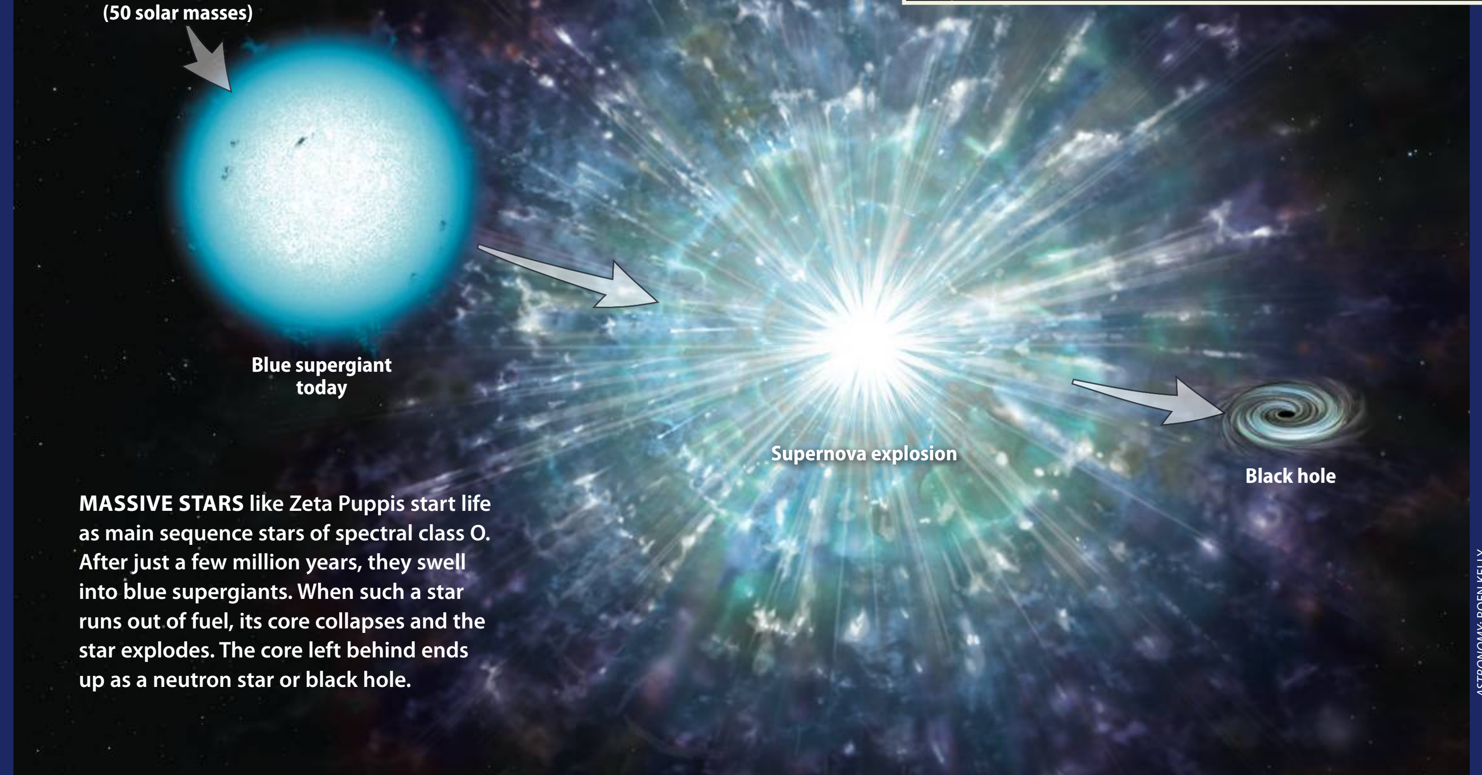
THE STAR CLUSTER HODGE 301 (at lower right) formed within the past several million years out of gas and dust in the Tarantula Nebula, located in the Milky Way's satellite galaxy, the Large Magellanic Cloud. Despite its relative youth, the cluster has already seen some massive stars complete their lives and explode as supernovae. Shock waves from the explosions have compressed some of the Tarantula's gas into sheets and filaments.



STARS LIKE THE SUN spend roughly 10 billion years on the main sequence. Once the Sun uses up its hydrogen fuel, it will expand into a red giant and cast off its outer layers, forming a planetary nebula. The core will settle down as a white dwarf.

ASTRONOMY: ROEN KELLY



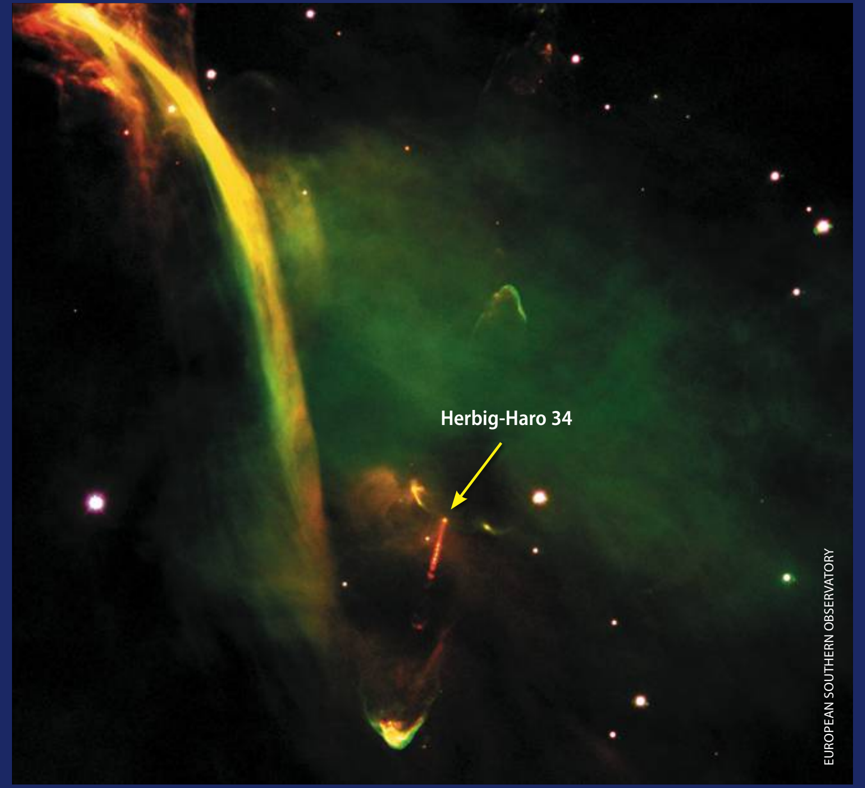


MASSIVE STARS like Zeta Puppis start life as main sequence stars of spectral class O. After just a few million years, they swell into blue supergiants. When such a star runs out of fuel, its core collapses and the star explodes. The core left behind ends up as a neutron star or black hole.

ASTRONOMY: ROEN KELLY

NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

STARS USUALLY FORM IN CLUSTERS. Some become globular clusters like M80, which contains hundreds of thousands of stars held together by their mutual gravitational attraction. All of the Milky Way's globular clusters formed at the same time the galaxy did, and orbit within the galaxy's halo. Globulars contain so many stars, their gravity has held them together since the galaxy's birth 13 billion years ago.



EUROPEAN SOUTHERN OBSERVATORY

THE FINAL FITS AND STARTS before a star fully forms show up in the protostar Herbig-Haro 34, located 1,500 light-years away near the Orion Nebula. The protostar has ejected two opposite jets of dense gas into the surrounding interstellar medium at speeds of 150 miles per second. The jets imply repeated outbursts arise when large chunks of material from a surrounding disk falls onto the protostar.

The secret lives of stars

Stars are born in gaseous clouds, live long, unassuming lives, and die in sometimes dramatic ways. /// BY RICHARD TALCOTT

Astronomy magazine

If you want to learn about stars, take a census of the heavens. You'll soon find a major complication, however — the results depend on how you define the search. Examine the brightest stars, and you'll discover lots of giant and supergiant ones, with only a smattering of main sequence stars like the Sun. Study the nearest stars, and you'll find almost all belong to the main sequence — and most are far cooler and dimmer than the Sun.

The brightest stars stand out because they pour huge amounts of energy into space. The supergiant Deneb radiates nearly 100,000 times as much light as the Sun and more than a billion times as much as nearby Proxima Centauri. But the bright, hot stars pay for their profligacy. They run through their nuclear fuel reserves far faster than their fainter, cooler cousins. The O5 star Zeta Puppis will survive only a few million years; M5.5 star Proxima Centauri will be around long after the Sun ceases to exist, and will look much as it does today when the universe is 100 times its current age.

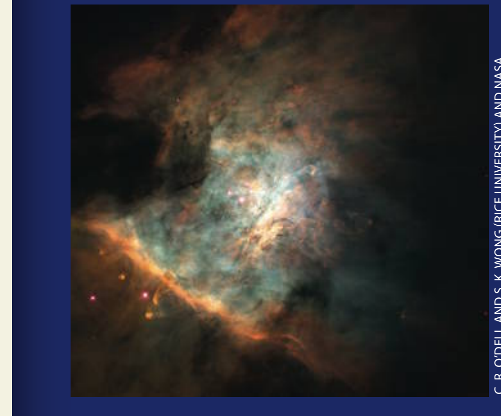
Astronomy's poster summarizes the nearest and brightest stars, as well as the big and small and the hot and cool. It's your complete guide to the births, lives, and deaths of the Milky Way's basic building blocks. A

/// THE 25 BRIGHTEST STARS

Name	R. A.	Dec.	Mag.	Abs. mag.	Spectral type	Luminosity class	Distance
Sirius*	6h45.1m	–16°43'	–1.47	1.4	A1	V	8.58
Canopus	6h24.0m	–52°42'	–0.72	–5.6	F0	II	313
Alpha Centauri*	14h39.6m	–60°50'	–0.29	4.1	G2	V	4.36
Arcturus	14h15.7m	19°11'	–0.04	–0.3	K1.5	III	36.7
Vega*	18h36.9m	38°47'	0.03	0.6	A0	V	25.3
Capella*	5h16.7m	46°00'	0.08	–0.5	G5	III	42.2
Rigel*	5h14.5m	–8°12'	0.12	–6.8	B8	Iab	773
Procyon*	7h39.3m	5°13'	0.34	2.6	F5	IV–V	11.4
Achernar	1h37.7m	–57°14'	0.50	–2.7	B3	V	144
Betelgeuse*	5h55.2m	7°24'	0.58	–5.0	M2	Iab	522
Beta Centauri*	14h03.8m	–60°22'	0.60	–5.4	B1	III	525
Altair*	19h50.8m	8°52'	0.77	2.2	A7	V	16.8
Aldebaran*	4h35.9m	16°31'	0.85	–0.7	K5	III	65.1
Acrux*	12h26.6m	–63°06'	0.94	–4.0	B1	IV	321
Spica*	13h25.2m	–11°10'	1.04	–3.5	B1	III–IV	262
Antares*	16h29.4m	–26°26'	1.09	–5.2	M1.5	Ib	604
Pollux*	7h45.3m	28°02'	1.15	0.8	K0	III	37.6
Fomalhaut	22h57.7m	–29°37'	1.16	1.7	A3	V	25.1
Deneb*	20h41.4m	45°17'	1.25	–7.5	A2	Ia	1,500
Mimosa*	12h47.7m	–59°41'	1.30	–3.9	B0.5	IV	352
Regulus*	10h08.4m	11°58'	1.35	–0.5	B7	V	77.5
Adhara*	6h58.6m	–28°58'	1.51	–4.1	B2	Iab	431
Castor*	7h34.6m	31°53'	1.59	0.6	A2	V	51.5
Shaula*	17h33.6m	–37°06'	1.62	–3.6	B2	IV	359
Gamma Crucis*	12h31.2m	–57°07'	1.63	–0.5	M3.5	III	87.9

* Stars with more than one component. Magnitudes combine all components; spectral types just the brightest member. (The H–R diagram on the other side plots only the brightest component.)

R. A. and Dec.: Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Apparent visual magnitude. **Abs. mag.:** Absolute visual magnitude (apparent magnitude if star lay 32.6 light-years away). **Spectral type and luminosity class:** Based on the Morgan–Keenan system. **Distance:** Measured in light-years.

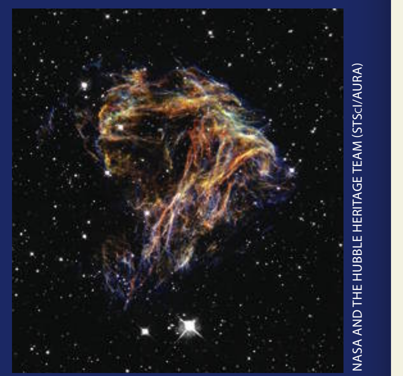


C. R. O'DELL AND S. K. WONG (RICE UNIVERSITY) AND NASA

STARS BEGIN TO EMERGE from the Orion Nebula, a massive star-forming region known to observers around the world. In this visible-light image, the four brightest stars — called the Trapezium — show up just left of center. These hot O-type stars radiate much of the energy needed to energize the nebula. They are the vanguard in what eventually will be a huge star cluster.

NASA, ESA, C. R. O'DELL (VANDERBILT)

WHEN A SUN-LIKE STAR exhausts its nuclear fuel, it swells into a red giant and eventually puffs off its outer layers. The Helix Nebula is a nearby example. After about 100,000 years, the expanding shell will become too tenuous to see. All that will be left is a faint white dwarf — the eventual fate of the Sun and most other stars with up to 8 solar masses.



NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

THE TATTERED REMAINS of a massive star rush outward in the supernova remnant N 49. The heavy elements forged by the progenitor star get blasted into space, where they eventually will be the raw material for a new generation of stars. That's how the Sun and its planets acquired heavy elements like gold and silver. After the explosion, the star's collapsed core ends up either as a neutron star or black hole.

/// THE 25 NEAREST STAR SYSTEMS

Name	R. A.	Dec.	Mag.	Abs. mag.	Spectral type	Luminosity class	Distance
Proxima Centauri	14h29.7m	–62°41'	11.05	15.5	M5.5	V	4.22
Alpha Centauri*	14h39.6m	–60°50'	–0.29	4.1	G2	V	4.36
Barnard's Star	17h57.8m	4°42'	9.54	13.2	M4	V	5.96
Wolf 359	10h56.5m	7°01'	13.54	16.7	M5.5	V	7.78
Lalande 21185	11h03.3m	35°58'	7.49	10.5	M2	V	8.29
Sirius*	6h45.1m	–16°43'	–1.47	1.4	A1	V	8.58
UV Ceti*	1h39.0m	–17°57'	12.52	15.4	M5.5	V	8.72
Ross 154	18h49.8m	–23°50'	10.95	13.6	M3.5	V	9.68
Ross 248	23h41.9m	44°11'	12.28	14.8	M5.5	V	10.3
Epsilon Eridani	3h32.9m	–9°27'	3.73	6.2	K2	V	10.5
Lacaille 9352	23h05.9m	–35°51'	7.34	9.8	M0.5	V	10.7
Ross 128	11h47.7m	0°48'	11.08	13.5	M4	V	10.9
EZ Aquarii*	22h38.6m	–15°18'	12.18	14.5	M5.5	V	11.3
Procyon*	7h39.3m	5°13'	0.34	2.6	F5	IV–V	11.4
61 Cygni*	21h06.9m	38°45'	5.21	7.5	K5	V	11.4
Gliese 725*	18h42.8m	59°38'	8.91	11.2	M3	V	11.5
Gliese 15*	0h18.4m	44°01'	8.07	10.3	M1.5	V	11.6
Epsilon Indi*	22h03.4m	–56°47'	4.69	6.9	K4.5	V	11.8
DX Cancri	8h29.8m	26°47'	14.81	17.0	M6	V	11.8
Tau Ceti	1h44.1m	–15°56'	3.50	5.7	G8	V	11.9
Gliese 1061	3h36.0m	–44°31'	13.03	15.2	M5.5	V	12.0
YZ Ceti	1h12.5m	–17°00'	11.60	13.7	M4.5	V	12.1
Luyten's Star	7h27.4m	5°14'	9.89	12.0	M3.5	V	12.4
SO 0253–1652	2h55.2m	16°17'	15.40	17.5	M7	V	12.5
Kapteyn's Star	5h11.7m	–45°01'	8.89	10.9	M1	V	12.8

* Stars with more than one component. Magnitudes combine all components; spectral types just the brightest member. Most astronomers think Proxima Centauri is an outlying member of the Alpha Centauri system.

R. A. and Dec.: Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Apparent visual magnitude. **Abs. mag.:** Absolute visual magnitude (apparent magnitude if star lay 32.6 light-years away). **Spectral type and luminosity class:** Based on the Morgan–Keenan system. **Distance:** Measured in light-years, based on observations by the European Space Agency's Hipparcos satellite.

/// STELLAR SPECTRAL CLASSES

Spectral class	color	Surface temperature (Kelvin)	Main sequence mass (Sun=1)	Main sequence radius (Sun=1)	Lifetime (years)	Examples
O	blue	greater than 31,000	20–120	12–25	less than 6 million	Zeta Puppis
B	blue-white	10,000–31,000	4–20	4–12	6–300 million	Rigel, Spica
A	white	7,400–10,000	2–4	1.5–4	300 million–1.8 billion	Sirius, Vega
F	yellow-white	6,000–7,400	1.05–2	1.1–1.5	1.8–8.8 billion	Canopus, Procyon
G	yellow	5,300–6,000	0.8–1.05	0.85–1.1	8.8–17 billion	Sun, Capella
K	orange	3,900–5,300	0.5–0.8	0.6–0.85	17–55 billion	Aldebaran, Arcturus
M	red	2,200–3,900	0.08–0.5	0.1–0.6	55 billion–5.5 trillion	Antares, Betelgeuse